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AN ECONOMIC ANALYSIS OF TWO GROUNDWATER ALLOCATION PROGRAMS FOR THE SALINAS VALLEY

by

Thomas C. Luetzow
Lieutenant, United States Naval Reserve
B.S., University of Wisconsin - Madison, 1983

Submitted in partial fulfillment
of the requirements for the degree of

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13. ABSTRACT (*Maximum 200 words*)

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The thesis analyzes representative water users from the Urban, Industrial and Agricultural sectors of the valley. A marginal cost curve for reducing water use is developed for each representative. These curves are used to determine the compliance costs for each allocation plan.

This study concludes that the free market allocation program is more efficient than the MCWRA's allocation program, assuming both plans use similar water use monitoring systems. Furthermore, the current MCWRA allocation program does not prevent overdrafting in the SVGB.

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EXECUTIVE SUMMARY

This thesis compares the economic cost of the Monterey County Water Resources Agency (MCWRA) groundwater allocation plan for the Salinas Valley Groundwater Basin (SVGB) to a proposed free market allocation plan using transferable water rights. This analysis develops a detailed free market allocation program. This free market allocation plan is patterned after the South Coast Air Quality Management District's Regional Clean Air Incentives Market Program in Los Angeles, California.

This thesis analyzes the Urban, Industrial and Agricultural sectors of the Salinas Valley. For each sector, representative businesses or organizations were selected and asked to participate. Each participant was analyzed, and marginal cost curves for reducing water consumption were developed to determine compliance costs for each allocation plan. The Urban sector participants include the City of Salinas, the California Water Service Company, Inc. and the Marina Coast Water District. The Industrial sector's representative was J. M. Smucker Company. The Agricultural sector included sixteen farms located throughout the valley. Farms were selected by their ability to provide historical data on crop type, acreage and yield information, as well as growing and packing costs per acre.

The thesis further examines the implementation costs of the MCWRA's allocation plan verses the theoretical free market allocation plan. It also estimates implementation costs for both plans, including the initial investment in office facilities and water use monitoring equipment, and monthly operational costs.

This study concludes that the free market allocation program is more efficient than the MCWRA's allocation program assuming both plans use similar water use monitoring systems. Furthermore, the current MCWRA's allocation does not bring the groundwater basin into balance. The groundwater being extracted annually from the basin is greater than the amount of water that is annually recharged into the basin. This result demonstrates that the MCWRA is not complying with the California State Water Board requirement for the agency to eliminate overdrafting in the Salinas Valley Groundwater Basin [Ref. 30].

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I. INTRODUCTION

A. OVERVIEW

The Salinas Valley is currently experiencing a serious groundwater allocation problem which is reducing groundwater quality and quantity. This deterioration has occurred because the demand for water is greater than the natural and augmented recharge capabilities of the Salinas Valley Groundwater Basin (SVGB). Excessive groundwater pumping from the SVGB has caused serious chronic overdraft conditions in the northern half of the Valley.[1]

The annual historical overdraft (1970-1992) is estimated by Montgomery Watson Engineering to have averaged 37,000 acre-foot (ac-ft) per year [Ref. 2:p. 5-14]. It also has been estimated that approximately 750,000 ac-ft of groundwater has been cumulatively overpumped during the six year period between 1986 and 1992 [Ref. 1:p. X].

This chronic overdrafting has seriously reduced groundwater levels in the northern half of the valley. In August of 1992, the groundwater levels in this region reached the lowest levels in recorded history. [Ref. 1:p. X] The northwest corner of the valley has experienced the greatest change. The

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[1]Overdraft occurs when groundwater is being extracted from the basin at a greater rate than it is being replenished.

groundwater elevation has dropped approximately 85 feet since 1930 [Ref. 2:p. 2-6].

Lowering the water table affects the valley in two ways: it increases the cost of extracting groundwater, and it accelerates seawater intrusion into the aquifer along the coast. Groundwater extraction costs have been estimated to increase $0.10 per ac-ft for every vertical foot the groundwater level drops, assuming that extraction volume remains the same. [Ref. 3] The total cost of lowering the water table by one vertical foot throughout the valley would be approximately $53,500 annually.

The seawater intrusion effect is the more significant of the two effects. Seawater intrusion is currently occurring along the coast at a rate of 16,700 ac-ft per year [Ref. 2:p. 8-3]. Seawater intrusion is caused by overdrafting in front of the seawater/freshwater interface [Ref. 1:p. 31]. This causes the freshwater gradient to shift from its predominately westward to an eastward movement. This reversal has accelerated seawater intrusion into the coastal aquifers. This seawater intrusion front poses an imminent threat to the municipal water supply for the City of Salinas. It is possible that the seawater presently confined in the "180 foot aquifer," located along the coast, could gain access to the

unconfined portion of the Salinas Valley groundwater basin.[2] This would endanger the municipal water supplies of several communities and thousands of acres of farmland.

Overdrafting, the six year drought affecting the Salinas Valley and the lack of new water supply projects have made it imperative that local communities stop overdrafting the SVGB to hold the seawater intrusion front. One of the primary steps required to achieve these goals is to develop a water allocation plan that would bring the basin back into balance and assure all parties equal access to this valuable resource.[3]

The Monterey County Water Resources Agency (MCWRA) and the Monterey County Board of Supervisors are the government agencies tasked by the State of California via the State Water Resources Control Board to develop and execute a program to prevent further groundwater overdrafting and seawater intrusion. The MCWRA has complete authority under the Monterey County Water Resources Agency Act (Stats. 1990, Chap. 1159) to establish any ordinances, reasonable procedures, rules, and regulations that would conserve water for present

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[2]The "180 foot aquifer" is a confined water-bearing strata located at an elevation of 180 feet below the ground. See Chapter II, Section D of this thesis for further hydrogeologic description of the Salinas Valley Groundwater Basin.

[3]Balance is a state of equilibrium where the amount of groundwater being extracted from the basin is equal to the basin's natural and supplemental recharge.

and future use within the SVGB and to prevent groundwater extractions which are harmful to the groundwater basin.

The MCWRA has two strategies to achieve these goals. The first strategy is to develop new water sources and/or increase the efficiency of the natural and augmented recharge capabilities of the SVGB. The second strategy is to develop a program to manage water demand for the valley. This is accomplished by enacting ordinances enabling the agency to monitor and control groundwater use and to set upper pumping limits for all commercial, industrial and municipal wells in the Salinas Valley. Such ordinances have been enacted over the past three years. Through these actions, the MCWRA has slowly established a water allocation plan based on a regulatory system of control.[4]

Currently, the State Water Resources Control Board believes that the current MCWRA allocation plan is inadequate for the Salinas Valley Groundwater Basin [Ref. 30:p. 1]. When senior MCWRA staff members were asked if any other allocation plan was given serious thought, they indicated that the only other allocation plan discussed was a tax based allocation plan. [Ref. 4] No serious consideration has yet been given to a free market allocation system. It appears the agency and

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[4]In a regulatory control system, the government agency determines the amount of a given natural resource (i.e., water) that any group or industry will be allowed to use.

the general public have not seriously considered the free market allocation method.

Since the economic community considers free market allocation to be the most efficient way of allocating a scarce resource, this thesis will examine a free market approach to groundwater allocation in the SVGB. This research examines the advantages and disadvantages of three methods for allocating groundwater and examines whether a specific free market allocation plan would be more efficient than the current MCWRA allocation plan. The information derived from this research will provide the MCWRA, local community leaders and the State Water Resources Control Board with some critical insight into the free market allocation method and the potential benefits it could bring to the valley.

B. RESEARCH OBJECTIVES AND QUESTIONS

The primary objective of this research is to determine if a free market (privatization) allocation plan is more economically efficient[5] than the MCWRA's allocation plan for a small

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[5]Economic efficiency refers to "the relationship between the monetary value of ends and the monetary value of means. The valuations that are counted are, consequently, the valuations of those who are willing and able to support their preferences by offering money.

From this perspective a parcel of land is used with maximum economic efficiency when it comes under the control of the party who is willing (which implies able) to pay the largest amount of money to obtain that control. The proof that a particular resource is being used efficiently is that no one is willing to pay more in order to divert it to some other use" [Ref. 12:pp. 9-10].

sample group. This will be accomplished by analyzing the cost impacts of the two plans on a small sample composed of the following segments of the valley: the industrial segment (an agricultural processor), the urban segment (City of Salinas, Marina Coast Water District, California Water Service Company, Inc.) and the agricultural segment (16 farms located throughout the valley). These three segments were selected because they use the most groundwater in the valley.

In order to achieve the main objective of this research, the following specific research questions will be answered:

- What are the theoretical advantages and disadvantages of the regulatory control allocation method, taxation allocation method, and privatization allocation method?

- Can a privatization allocation plan be legally adopted based on the current regulations and authority of the MCWRA?

- What would be the organizational structure as well as the operating procedures and guidelines for a privatization allocation program in the Salinas Valley?

- What would the estimated costs be for initial capital expenditures and operation of a privatized allocation program for the Salinas Valley? How would these costs compare to the regulatory allocation program?

- How would the estimated compliance costs for the privatization program compare to the estimated compliance costs of the regulatory allocation program?

C. METHODOLOGY

For each market segment, the marginal cost of conservation will be estimated and a cost of compliance determined for each allocation plan based on the subsample's projected water use

in 1994, 1995, and 1996. This information will show local decision makers the economic trade-offs between a free market allocation plan and the MCWRA's allocation plan.

Also this thesis estimates the cost of implementing both allocation plans. Implementation costs are based on historical cost data obtained from the Monterey County and estimates received from the private sector.

D. LIMITATIONS AND ASSUMPTIONS

The major limitation in developing accurate compliance costs for the urban and agricultural sectors is obtaining accurate historical water use data. In the agricultural sector, historical water use data does not exist. There is no accurate information available about the amount of water normally applied per acre by crop type in the Salinas Valley. Therefore, this analysis assumes that the agricultural water use per acre equals the average water use per acre of irrigated crop land. This average is derived from the Montgomery Watson Groundwater model statistics [Ref. 2:pp. 2-3 & 4-15].

In the urban sector, the City of Salinas had no annual water use records except for 1987. Therefore, for the City of Salinas it is assumed that historical water use per capita is constant. The City of Salinas's historical water use for 1988 through 1993 is derived by multiplying historical water use per capita for 1987 by annual population estimate for the

relevant year. All projected water use figures for the urban sector were obtained from official Urban Water Allocation Plans submitted to MCWRA by the City of Salinas, Marina Coast Water District and California Water Service Company.

Another significant limitation is the inability to obtain information about irrigation efficiencies by crop type for the different methods of irrigation. This data is essential to identify the irrigation method that achieves the highest water efficiency and to determine the marginal cost of saving an acre-foot of water by improving irrigation methods. However, there is accurate data about distribution uniformity for the different methods of irrigation used in the valley. Distribution uniformity (DU) equals irrigation efficiency (IE) (if one does not take into account application losses) when the amount of beneficially used water is the same as the average amount infiltrated in the low quarter.[6] Therefore, "DU may be considered as the maximum potential IE of a properly managed irrigation system, if under-irrigation is to be avoided" [Ref. 5:p. 6]. This thesis assumes that irrigation efficiency is the same as DU. This assumption generally agrees with the historical irrigation efficiency data presented in Chapter V.

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[6]The low quarter is the average depth of water infiltrated in the 25% of the areas receiving the least amount of water.

The analysis for determining compliance costs for the free market allocation plan assumes that a sub-sample representative will be able to purchase or sell as much water at the prevailing market price as they desire.

E. SUMMARY OF FINDINGS

The most important findings of this research include:

- Based on the projected water use trends derived from this research sample group, the MCWRA's allocation program does not eliminate overdrafting in the Salinas Valley Groundwater basin.
- The MCWRA's allocation program reduces the amount of groundwater used per capita by 15% using 1987 as a baseline. However, it does not stop urban sector water use from increasing. The Association of Monterey Bay Area Governments projects that the urban population will continue to grow in the future.
- The comparative economic analysis indicates that the free market (privatization) allocation program is economically more efficient in reducing water use than the MCWRA's allocation program for the sample group, assuming similar water use monitoring procedures.
- The MCWRA's allocation program has a lower start-up cost than the free market program. This is because the free market plan uses a computerized well monitoring system. Implementation costs are relatively equal if both programs use similar well monitoring systems.

H. ORGANIZATION OF STUDY

This thesis is divided into six chapters. In Chapter II the relevant characteristics of the Salinas Valley are discussed, including climate conditions, historical land and water use, geologic conditions, hydrogeologic conditions, current problems with SVGB (overdrafting, seawater intrusion,

and nitrate contamination), the MCWRA Mission and Authority, and the steps taken to date by the MCWRA to prevent over-drafting and stop seawater intrusion.

Chapter III discusses the three primary methods of allocating a scarce resource. It outlines the current economic thought on the advantages and disadvantages of each.

Chapter IV describes a privatization allocation program for the SVGB. The legal authority of the MCWRA to implement such a program is discussed, along with a methodology for defining, issuing and trading water rights. The chapter also discusses the program's administrative, monitoring and enforcement requirements.

Chapter V estimates the cost of implementing and operating both the privatization allocation plan and the MCWRA's allocation plan. The chapter also compares the economic cost of compliance under both plans for a small sample group composed of urban, industrial and agricultural water users.

Chapter VI summarizes the major conclusions drawn from this research and highlights the research required to resolve outstanding issues.

II. BACKGROUND ON THE SALINAS VALLEY AND THE GROUNDWATER PROBLEMS

The Salinas Valley is located in the coastal region of north central California. This elongated valley is surrounded by the Gabilian mountain range to the east, the Elkhorn Slough to the northeast, and the Sierra de Salinas and Santa Lucia mountain ranges to the west. The altitude of the valley floor varies from zero to about 400 feet above sea level. The Salinas Valley Groundwater Basin (SVGB), which is the only source of fresh water for the valley, extends from Bradley, near the southeast end of the valley, to Monterey Bay, at the northwest end of the valley. The basin's width varies from about 10 miles near the Monterey Bay to about three miles near Bradley. The location for this study is shown in Figures 2-1 and 2-2 [Ref. 2:Fig. 2-1 & 4-2] The SVGB is legally controlled by the Monterey County Water Resource Agency (MCWRA).

A. CLIMATE CONDITIONS

The Salinas Valley is close to the Pacific Ocean and has a mild mediterranean climate. The area enjoys moderate temperatures with slight seasonal variations. The summers are cool and dry while the winters are mild and rainy. These moderate conditions are created by the mountains surrounding

Figure 2-1. Study Area

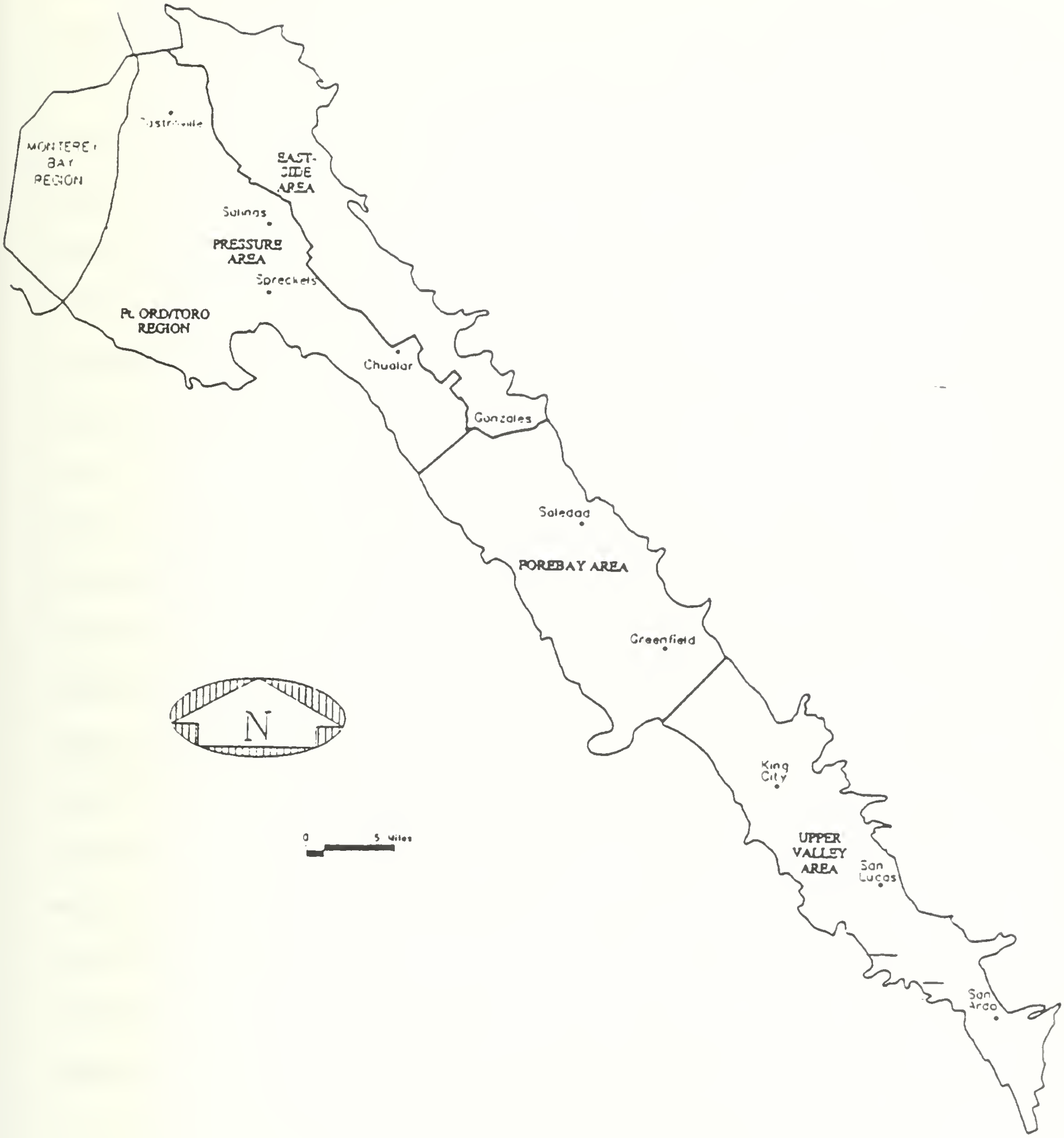

Figure 2-2. Study Subareas

the valley. They help retain warm air flows in the winter and cool air flows in the summer. The air flows are generated by temperature differences between the ocean and the land. The predominant winds are from the west and the northwest. Therefore, the ocean's influence decreases as one travels from the coast towards the southeast. This decrease, and a strong solar heating effect during the summer, explains why the valley's interior generally has higher average summer temperatures and lower average winter temperatures than the rest of the valley.

In the valley, precipitation increases as one travels from east to west and as elevation increases. An average rainfall of 60 inches per year occurs along the crest of the Santa Lucia Range. The Santa Lucia Range has the highest average rainfall in comparison to the other mountain ranges that surround Salinas Valley. The minimum average rainfall occurs at Soledad in the interior of the valley and amounts to only 11 inches per year. The mean annual precipitation in the mountain ranges surrounding the valley varies from about 20 inches near the Gabilan Range to about 25 inches in the Sierra de Salinas, excluding the area along the crest of the Santa Lucia Range. The mean annual precipitation in the interior of valley ranges from about 11 inches in Soledad to 14 inches at the Nacimiento and San Antonio Reservoirs. The majority of the rainfall occurs during the winter months (November - March), which accounts for more than 75% of the annual

rainfall. This is the only source of fresh water for recharging the SVGB. [Ref. 2:p. 2-2]

This combination of topography and climate provides the Salinas Valley with the ideal environment for farming and ranching. This climate gives the farming community year-round growing conditions, with 350 frost-free days near the coast and 200 - 250 frost-free days inland. These conditions allow the majority of farmers to plant two or three crops per year. The capacity for multiple crops is only limited by the growth rate of the crop and soil conditions.

B. HISTORICAL LAND AND WATER USE

Land use is a key element in determining which allocation plan will be more economically efficient. Land use directly affects water consumption rates. It also can affect the land's capacity to percolate rainwater, runoff and irrigation water. The three principal categories of land use are agricultural, urban (which includes residential, commercial and industrial areas) and native vegetation. In the SVGB, "agricultural land accounted for 47 percent followed by native vegetation with 46 percent, while urban land use was only 7 percent" [Ref. 2:p. 4-12] Figure 2-3 [Ref. 2:Fig. 4-10] shows the Salinas Valley land use distribution for 1990. Over the past twenty years, the ratio of urban versus agricultural

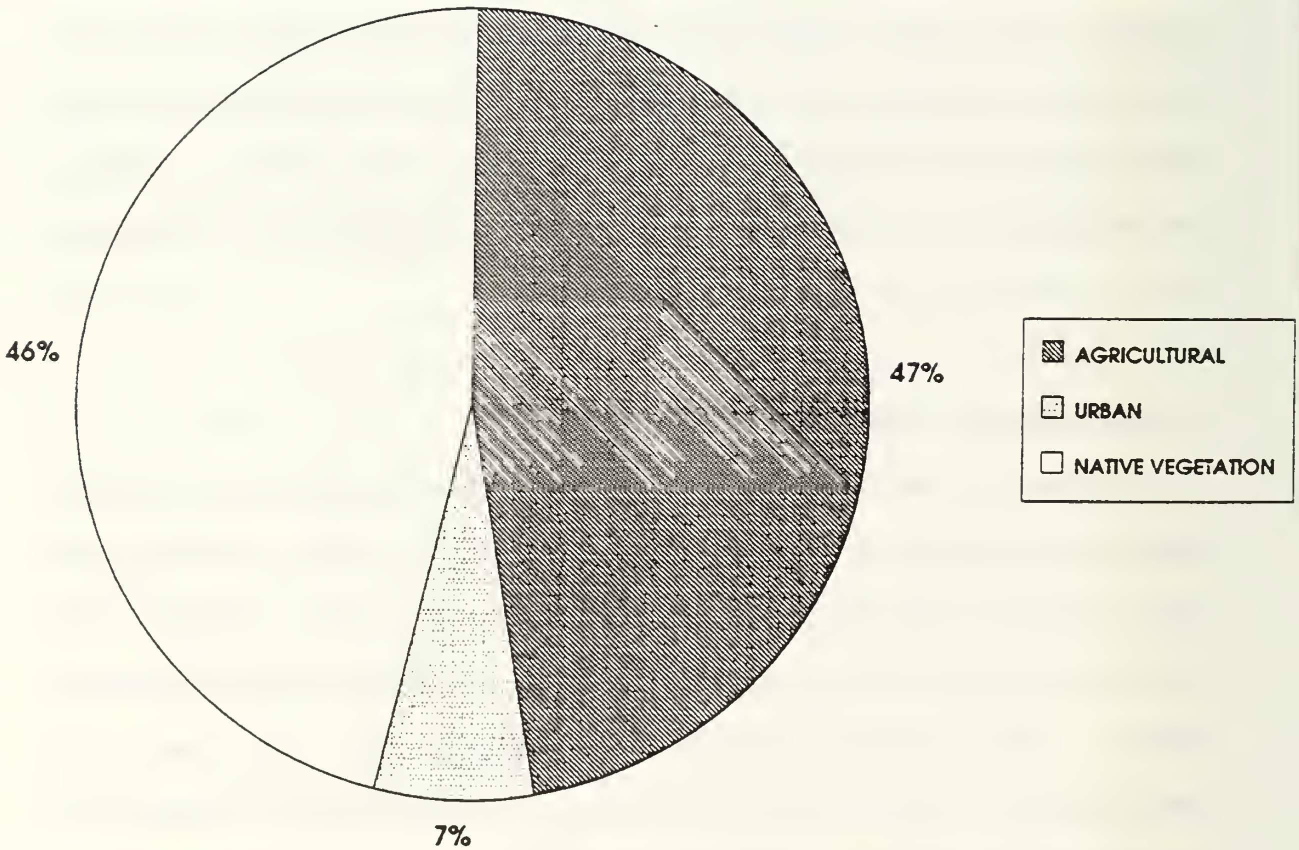

Figure 2-3. 1990 Land Use Distribution

acreage in the Salinas Valley has been relatively stable, even though there has been some conversion of farmland to urban use near the major urban areas (i.e., City of Salinas). Figure 2-4 [Ref. 2:Fig. 4-9] shows that the ratio between agricultural and urban land use has been relatively constant between 1970 and 1985. Urban acreage has grown slightly as farmland is converted to urban uses.

Agricultural production is the largest industry in the county. In fact, Monterey is the number one vegetable producing county in the nation [Ref. 6:p. 2]. According to the Monterey County Agricultural Commissioner, the Salinas Valley produces 95 percent of the artichokes, 55 percent of the broccoli, 35 percent of the cauliflower, 30 percent of the lettuce, and 20 percent of the celery grown in the United States. Agricultural sales in the county in 1993 exceeded 1.8 billion dollars. [Ref. 7:p. i] The preceding data reflects the sensitivity that groundwater allocation has on the local economy since this industry uses 90% of the groundwater extracted from the SVGB. In Monterey County, the four row crops with the highest dollar value in 1990 were lettuce, broccoli, strawberries and cauliflower [Ref. 7:p. 30].

Based on the most current estimates (1991) from the United States Bureau of Reclamation's (USBR) Geographic Information System (GIS), 197,827 acres of land are being used for farming in the Salinas Valley. The majority of this land is irrigated

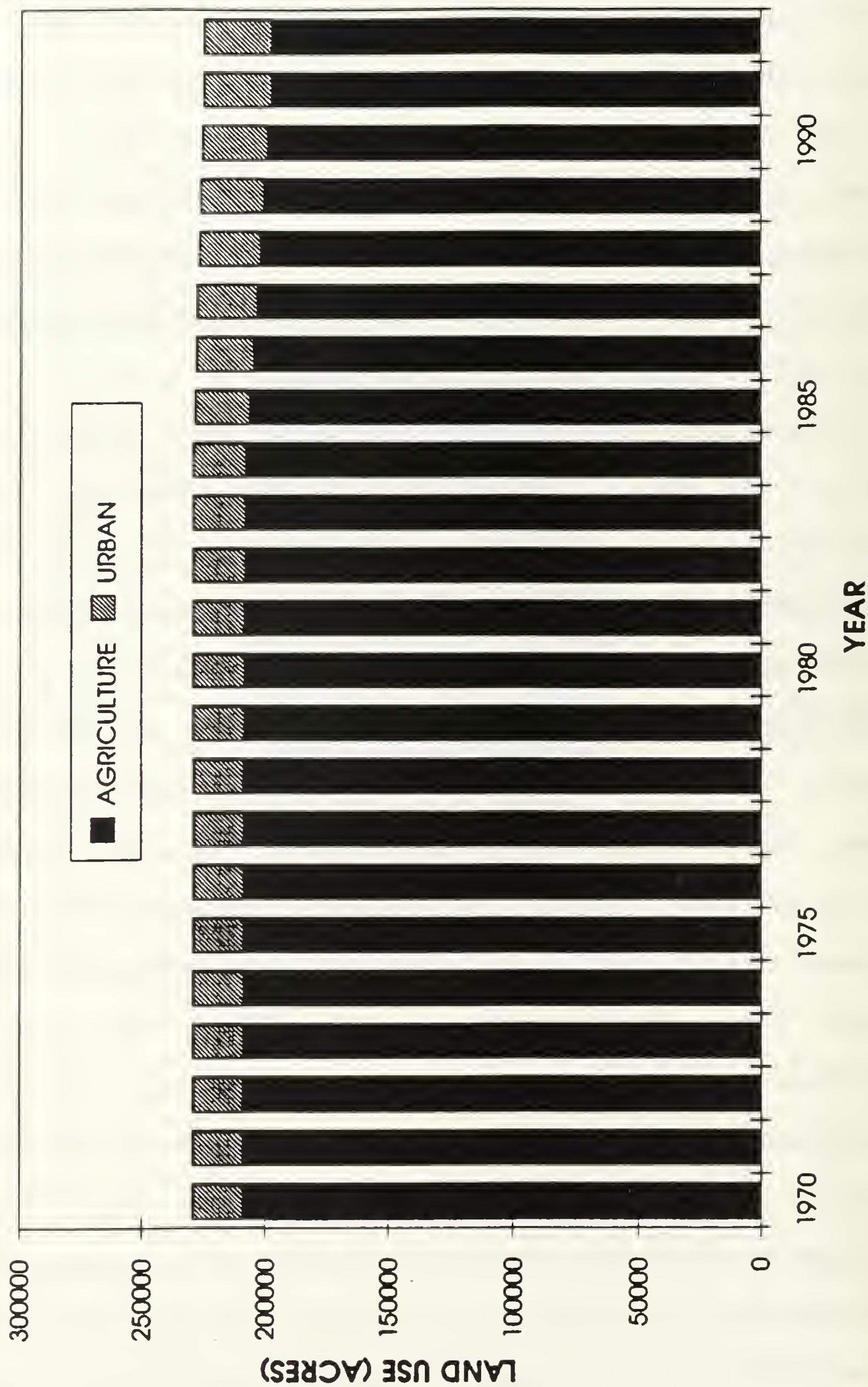

Figure 2-4. Agricultural Versus Urban Land Use

with ground water. According to the Montgomery Watson groundwater model, the agricultural community uses 512,000 acre-feet of water per year. This is 90.5% of the total groundwater extracted from the aquifer each year. This is an average of 2.588 acre-feet per acre of farmland. Future farming is projected to remain constant up to the year 2020 [Ref. 8:pp. 3-6]. It has also been estimated that 80 percent of the land in the valley could be irrigated; 65 percent is currently being irrigated [Ref. 9:p. 16]

A survey of eight fields conducted in March 1988 indicated that these fields were only achieving 58% average irrigation efficiency [Ref. 31:p. 7].[7] This is somewhat below the theoretical irrigation efficiencies that should be obtained under typical conditions and proper water management. It is also far below the ideal potential efficiency levels according

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[7] The term irrigation efficiency "is a measure of the proportion of water applied that is actually used beneficially. Irrigation efficiency (IE) is defined as:

IE = water beneficially used / total water applied

where beneficial uses include water necessary for:

* crop transpiration
* salinity control
* climate control (frost protection and crop cooling)

and beneficial uses do not include:

* application losses such as spray drift or uncollected run-off
* evaporation from wet soil surfaces or wet foliage
* deep percolation of water past the root zone (in excess of leaching requirement)." [Ref. 5:p. 4]

to documentation from the California Mobile Irrigation Labs (CMIL) [Ref. 5:p. 6]. The following Table 2-1 [Ref. 5:p. 6] presents irrigation efficiencies for a well designed irrigation system with excellent and average management.

TABLE 2-1. IRRIGATION EFFICIENCIES

Irrigation Method	IE (%) (Best)	IE (%) (Average)
Linear Move	90	70
Furrow	90	70
Drip	90	65
Hand Move Sprinkler	75	60

If a 58% average irrigation efficiency is typical in the Salinas Valley, the farming community is wasting somewhere between 2% and 32% of the groundwater used for irrigation. For every 10% decrease in efficiency, the farming community wastes an estimated 51,200 acre-feet of water per year. This estimate is based on the groundwater extracted per year for agriculture according to the Montgomery Watson model mentioned previously.

Urban and industrial centers are located in the city of Salinas (population 115,000) and the communities of Gonzales, Marina, King City, Soledad, Chualar, and Castroville. These urban areas have experienced tremendous growth during the last ten years. For example, population in Salinas has grown 37 percent during this time. The majority of the industrial base

in these urban areas is centered around the agricultural community and its needs.

Table 2-2 [Ref. 8:p. 3-3], developed by the Army Corps of Engineers, estimates the Salinas Valley's urban and industrial water demand for 1990 and 2010. It is based on

> [The] association of Monterey Bay Area Governments (AMBAG) population projections, estimates provided by the Monterey County Flood Control and Water Conservation District municipal demand estimates for Marina and Fort Ord by the Sea-water Intrusion Committee (December 1988), population estimates by the U.S. Bureau of Census (1971) and a survey of water use conducted by the District in cooperation with the County Planning Department (1984). [Ref. 8:p. 3-2]

In general, urban water use has increased slightly over the past twenty years. Figure 2-5 [Ref. 2:Fig. 4-12] shows the historical total annual water use for both the urban and agricultural sectors. The largest subcategory of urban water usage is residential.

Residential water use is expected to increase by 148.6% between 1980 and 2020 [Ref. 1:p. 48]. Table 2-3 [Ref. 1:p. 48] presents both the historical and projected annual residential water demands for major urban centers in the Salinas Valley.

TABLE 2-2. PROJECTED URBAN AND INDUSTRIAL WATER DEMAND

	Year 1988	Year 1990		Year 2010	
Community	Use Per Capita (gal/day)	Population	Demand (acre-feet/year)	Population	Demand (acre-feet/year)
Salinas	150	102,627	17,241	145,000	24,359
Castroville	175	5,177	1,015	6,650	1,301
Greenfield	133	7,290	1,586	8,510	1,268
Gonzales	154	5,750	893	6,175	1,065
King City	150	8,581	1,586	15,700	2,901
Soledad	99	8,090	897	9,750	1,081
Marina	106[8]	21,012	3,800	37,879	6,400
Fort Ord	N/A	30,460	8,200	32,124	8,260
San Ardo	215	460	111	580	118
Spreckels	201	580	151	460	130
Chualar	154	580	97	700	118
San Lucas	148	202	33	240	40
Unincorporated	140	30,551	4,790	42,122	6,605
Industrial			2,305		2,305
		220,880	42,204	306,200	55,957

[8]This data was provided by Richard Youngblood of the Marina Coast Water District. [Ref. 3]

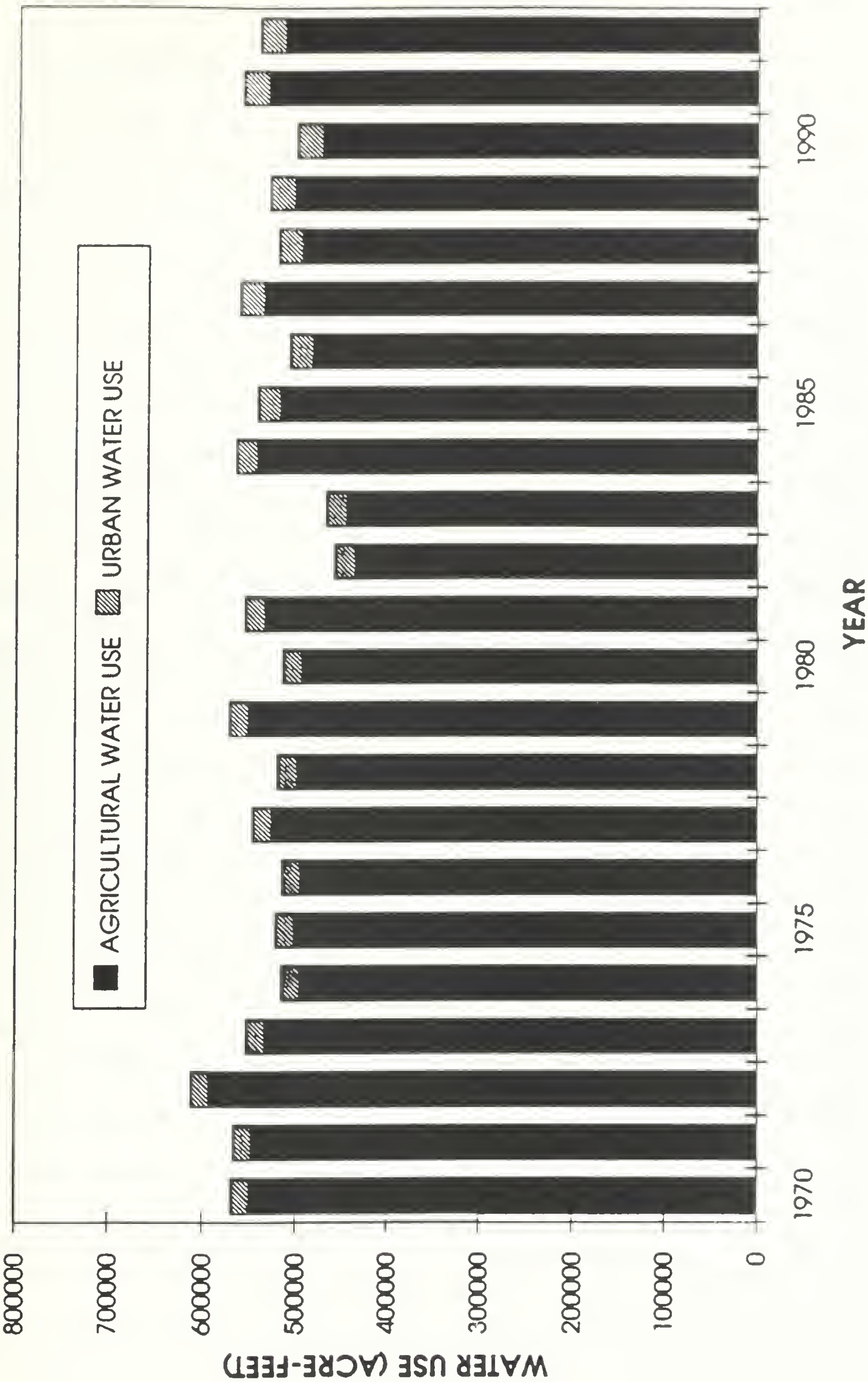


Figure 2-5. Total Annual Water Use

TABLE 2-3. HISTORICAL AND PROJECTED ANNUAL RESIDENTIAL WATER DEMAND

	1980 (ac-ft/yr)	2020 (ac-ft/yr)
Salinas	12,721	32,689
Gonzales	663	936
Soledad	801	1,922
Greenfield	479	1,203
King City	1,009	2,220
Total	15,673	38,970

Residential water use includes water used indoors and outdoors. An estimated 60 percent of urban water use is for indoor applications; the remaining 40 percent is for outdoor purposes. [Ref. 3] Indoor water consumption is relatively constant, while outdoor use varies with a demand cycle that is similar to the demand cycle for agricultural water use. Furthermore, water consumption varies with the type of dwelling. Apartments and condominiums usually have a lower water consumption per capita than a single family residency. Since irrigation systems are usually installed and maintained by professional irrigation experts, apartments and condominiums typically have lower landscape water requirements and higher irrigation efficiency.

The second largest subcategory of urban water use is commercial water use. Commercial water users are small businesses that use water mainly for indoor sanitation, personal consumption and landscaping. Examples of commercial

users are banks, food stores, restaurants and retail establishments. (Commercial laundries and car washes are included in the industrial category.) Commercial water use is expected to increase by 116.6% between 1980 and 2020 [Ref. 1:p. 49]. Table 2-4 [Ref. 1:p. 49] presents the historical and forecasted future annual commercial water demand for major urban centers in the Salinas Valley.

TABLE 2-4. HISTORICAL AND FUTURE ANNUAL COMMERCIAL WATER DEMAND

	1980 (ac-ft/yr)	2020 (ac-ft/yr)
Salinas	3,051	6,608
Gonzales	258	441
Soledad	311	546
Greenfield	186	608
King City	393	891
Total	4,199	9,094

Industrial users are the third largest subcategory of urban water users. Industrial water users are industries or businesses which use large volumes of water. Typical examples of industrial users are food processing plants (fruit, vegetables and seafood), beverage bottling plants (wineries and soft drink producers), commercial ice manufacturers, laundries, and car washes. This category is expected to increase by 100.9% between 1980 and 2020 [Ref. 1:p. 49]. Table 2-5 [Ref. 1:p. 49] presents the historical and future

annual industrial water demand for major urban centers in the Salinas Valley.

TABLE 2-5. HISTORICAL AND FUTURE ANNUAL INDUSTRIAL WATER DEMAND

	1980 (ac-ft/yr)	2020 (ac-ft/yr)
Salinas	515	1,058
Gonzales	87	89
Soledad	105	182
Greenfield	63	124
King City	132	359
Total =	902	1,812

The last urban subcategory is the general public subcategory. This subcategory includes government institutions such as public buildings, schools, prisons, public hospitals, fire departments, state, county, and city parks, as well as national parks and military installations. The general public water demand is expected to increase by 120.9% between 1980 and 2020. [Ref. 1:p. 50] Table 2-6 [Ref. 1:p. 50] presents the historical and future annual general public water demand for major urban centers in the Salinas Valley.

TABLE 2-6. HISTORICAL AND FUTURE ANNUAL GENERAL PUBLIC WATER DEMAND

	1980 (ac-ft/yr)	2020 (ac-ft/yr)
Salinas	50	125
Gonzales	37	55
Soledad	45	92
Greenfield	27	73
King City	56	130
Total =	215	475

Given these preceding projections for each subcategory, the annual water usage in the urban category will increase by an estimated 139.9% between 1980 and 2020.

C. GEOLOGIC CONDITIONS

Geologically, the Salinas Valley is a deep asymmetric valley which overlays a low-permeable formation of consolidated rock from the Tertiary Age and earlier. Unconsolidated marine and alluvial sediment cover this layer and form the Salinas Valley's permeable, water-bearing aquifers and the low permeability clay aquiclude[9].

The valley's shape and location derive from the tectonic history of north central California. The Salinas Valley runs parallel and west of the San Andreas Fault zone and has numerous faults that travel through the valley. The most

[9]The term aquiclude describes the groundwater-bearing properties of a rock formation. Aquicludes do not transmit water easily and do not yield water to wells, though they may retain much water in their fine pores [Ref. 14:p. 6].

famous faults are the Gabilan Fault, which is located on the east side of the valley, and the King City fault located on the west side. These faults along with the consolidated rock layer formations form the boundary of the groundwater basin.

The major geological features of the Salinas Valley are: the Granite Basement, Monterey Formation, Purisma Formation, Paso Robles Formation, and Quaternary/Recent Alluvium [Ref. 2:pp.2-4]. The Granite Basement occurs at depths from 100 to 2,600 ft. The upper 100-200 ft. of the granite is fractured and deteriorated. Limited quantities of water are believed to be available from this zone. However, this is not considered a viable groundwater supply due to the low yields, great depth, and the expense required to extract water from this zone. This formation is considered to be the base for groundwater exploration.

The Monterey Formation represents the bulk of the consolidated marine rocks sitting on top of the Granite Basement. It is primarily composed of massive mudstones. It also contains some sandstone beds close to its base. The sandstone units generally yield some water, but the mudstone beds do not. The sandstone beds in the Monterey formation provide most of the oil extracted in the San Ardo oil fields.

The Purisma formation consists of siltstones and sandstones. It is not considered a critical source of groundwater. The Paso Robles formation is a conglomerate which is composed primarily of fine to course sandstones,

mainly of fluvial origin. The Quaternary and the Recent Alluvium formations are composed of sands and gravel. They supply most of the groundwater in the Salinas Valley. The geology of the formation is very complex, with rapid changes in soil composition occurring both vertically and horizontally.

D. HYDROGEOLOGIC CONDITIONS

The Salinas Valley groundwater basin is generally composed of three major water-bearing strata or aquifers. The aquifers in the SVGB are broken into two classes: confined and unconfined. These aquifers are identified by their elevation below ground: the 180 foot aquifer, the 400 foot aquifer, and the deep aquifer. There is limited knowledge and data about the deep aquifer and the aquiclude that lies between the 400 foot aquifer and the deep aquifer.

An aquifer is basically a giant bathtub filled with water saturated coarse sand. This aquifer is constantly being recharged by surface water and/or rainwater through deep percolation. The hydrogeological definition of an aquifer is a saturated, permeable, geologic unit that transmits significant quantities of water under ordinary hydraulic gradients. A confined aquifer is an aquifer that is confined between two relatively impermeable geologic layers. An unconfined aquifer is an aquifer whose upper boundary is not

confined by an impermeable geologic layer. The upper boundary of an unconfined aquifer is the water table.

The Salinas Valley aquifer is recharged principally by the Salinas River and secondarily by rainfall in the valley. The Salinas River drains the surrounding 3,950 square miles of mountains and foothills. The river is about 170 miles long; the lower 93 miles flow through the floor of the valley on its north-western journey to the coast. It finally discharges into the Monterey Bay near Castroville.

All irrigation, domestic, municipal and industrial water requirements in this basin are supplied from the Salinas Valley groundwater basin, except for some limited acreage near Greenfield. There the residents receive supplemental water from the Arroyo Seco river (a tributary of the Salinas River).

In 1946, the California State Department of Water Resources subdivided this groundwater basin into four inter-connected hydrological regions (See Figure 2-2). The first region is the called the Upper Valley Area. It is identified as the southern end of the valley and has a gross area of 85,000 acres. The major urban centers within this area are San Ardo, San Lucas and King City. The second region is called the Forebay Area. It extends from the northern boundary of the Upper Valley to the city of Gonzales. It contains approximately 77,000 acres and two major urban areas: Greenfield and Soledad.

The third region is the East-Side Area. It's geographical boundaries are north of the Forebay Area, three miles south of city of Castroville and east of U.S. Highway 101. It contains 43,000 acres and two major urban areas: Santa Rita and the eastern suburbs of Salinas. The final region is the Pressure area. The area lies west of U.S. Highway 101 and extends north from the Forebay area to Monterey Bay. It contains 81,100 acres and five major urban areas: Castroville, Marina, Salinas except for the eastern suburbs, Chualar and Gonzales.

E. CURRENT PROBLEMS WITH SALINAS VALLEY GROUNDWATER BASIN

The Salinas Valley groundwater basin's current problems can be grouped into three categories: decreasing groundwater levels, seawater intrusion and nitrate contamination. These three problems are not independent. They are symptoms of a greater problem: the overdrafting of the groundwater basin. Overdrafting occurs when the amount of groundwater extracted is greater than the basin's natural ability to recharge itself. This is not an isolated problem but is occurring throughout the Salinas valley.

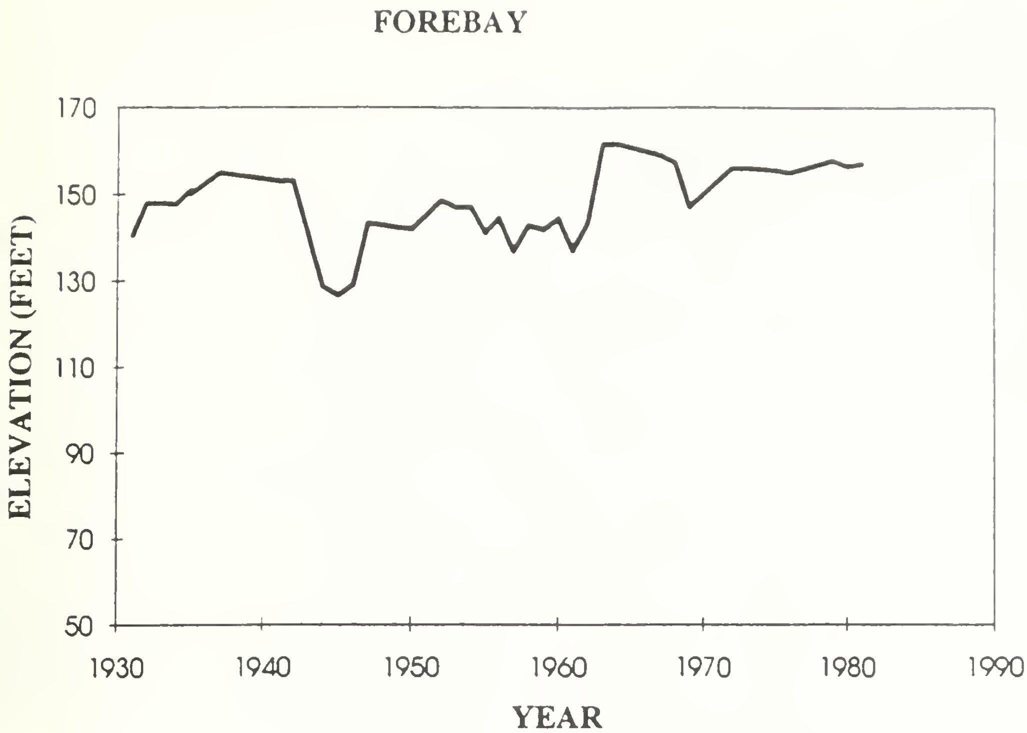
1. Lowering of Groundwater Levels (Overdrafting)

Groundwater levels generally will decline when extractions (through pumping) exceed the water inflow or recharge into the basin. Numerous locations throughout the

valley are experiencing significant declines in their groundwater level. Three times each year the Monterey County Water Resource Agency (MCWRA) measures the basin's groundwater levels.

Groundwater levels in the Forebay and Upper Valley areas have remained relatively constant for the last sixty years, except for the drought years (1987-90). These historical trends are shown in Figure 2-6 [Ref. 2:Fig. 2-6]. The groundwater level in the Forebay area has actually risen slightly over the last twenty years. The Nacimiento and San Antonio reservoirs, built in 1957 and 1965, contribute significantly to the stability of water levels in these areas [Ref. 2:p. 2-6]. They provide controlled releases of water which increase the ability of the Salinas River to percolate water to the basin year around. Controlled releases also avoid the waste that would occur if water was allowed to flow into the ocean. Without these reservoirs, the Salinas River would rise above its optimum flow rate for percolation during the rainy season, and water would be wasted to the ocean. During the late spring, summer and early fall this river would be a dry river bed.

The East side and the Pressure Area have experienced a slight drop in water levels during the past 50 years, as shown in Figure 2-7 [Ref. 2:Fig. 2-7]. The elevation of the water table in the East Side area has decreased approximately 85 feet since 1930. This decrease is greater than that of any



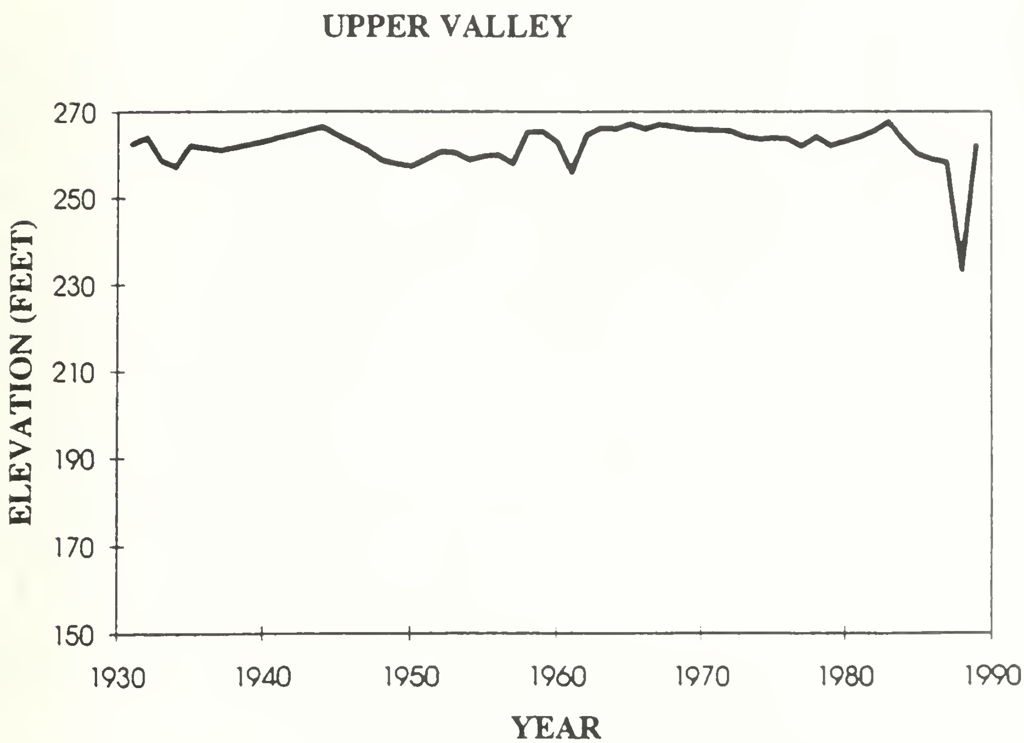
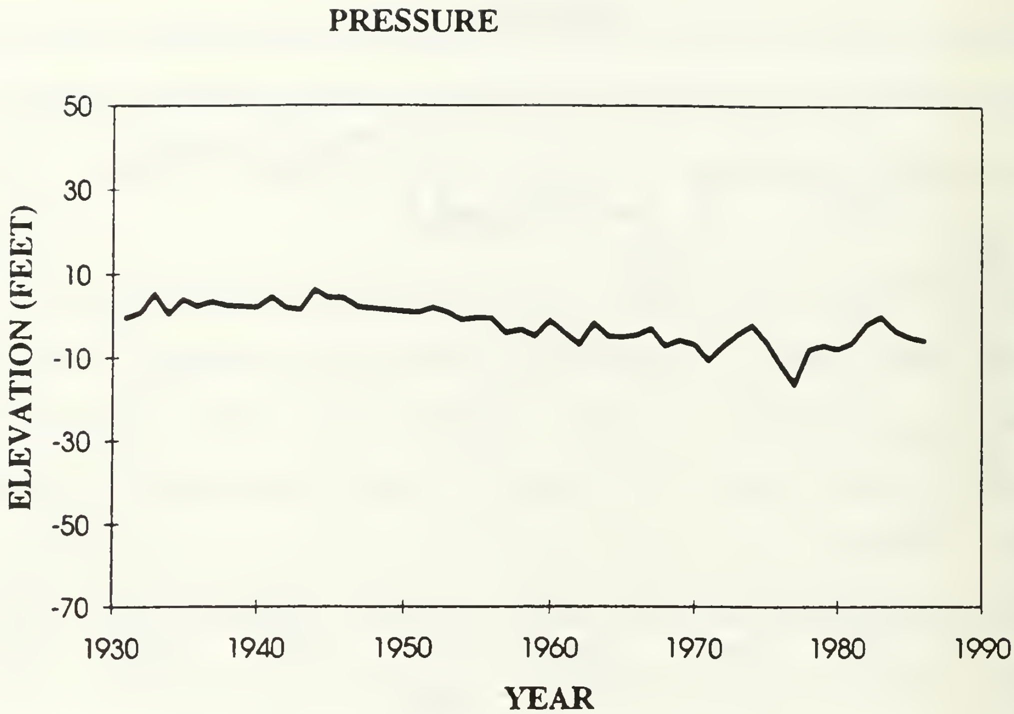


Figure 2-6. Historical Groundwater Levels in Forebay and Upper Valley



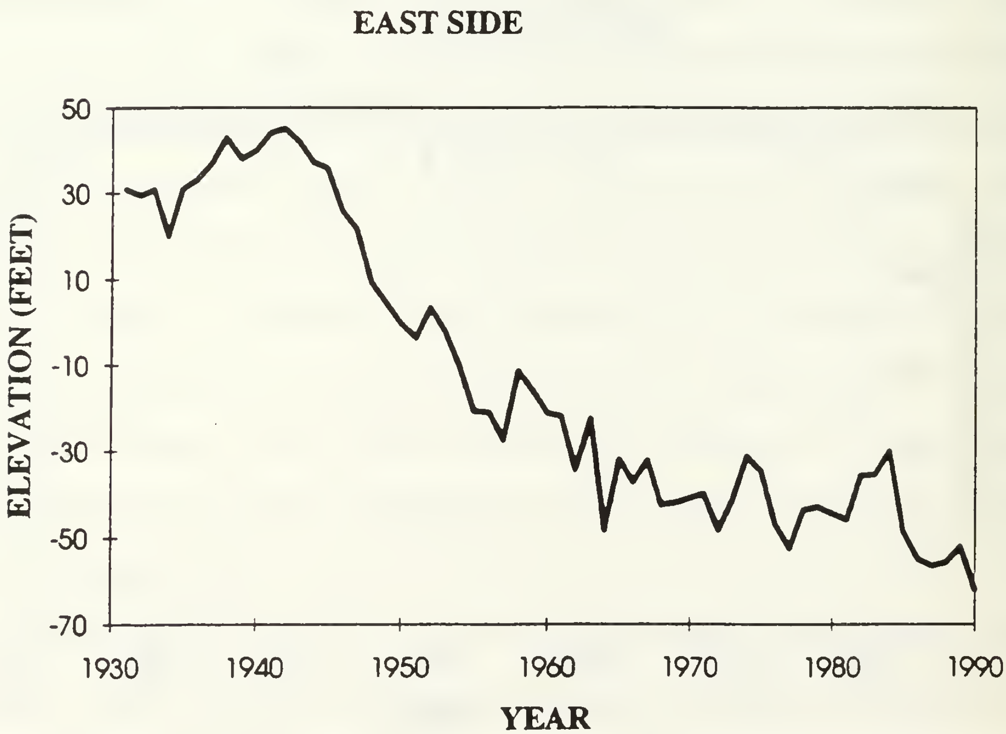


Figure 2-7. Historical Groundwater Levels in Pressure and East Side

other region in the SVGB. After 1965, the Pressure Area's 180-ft aquifer has appeared to stabilize. Well owners near the coast have been forced to abandon their wells due to seawater intrusion. These wells were replaced with wells that extract groundwater from the 400 ft. aquifer.

Figure 2-8 [Ref. 2:Fig. 2-9] shows that the aquifer as a whole has experienced a rapid decline in groundwater level since 1984. This data is somewhat skewed for the 180-ft. and 400-ft. aquifers near the coast. Seawater intrusion has maintained the groundwater level by supplementing lost freshwater with salt water.

These declines in groundwater levels result when groundwater pumping activity exceeds the natural recharge rate. This is illustrated by comparing the historical average total recharge with the historical extraction, using the Montgomery Watson groundwater model (See Table 2-7 [Ref. 2:Table 2-6]). This comparison shows that the Salinas Valley groundwater basin has been overdrafted by 37,000 acre-feet per year. Table 2-8 [Ref. 1:p. 24] gives the estimated groundwater basin deficits from 1987 to 1992.

Overdrafting affects the groundwater basin in two ways. First, the cost of extraction increases for individual well owners as the groundwater level drops. For every vertical foot the ground-water level drops, costs increase an estimated $0.10 per ac-ft of water extracted [Ref. 3].

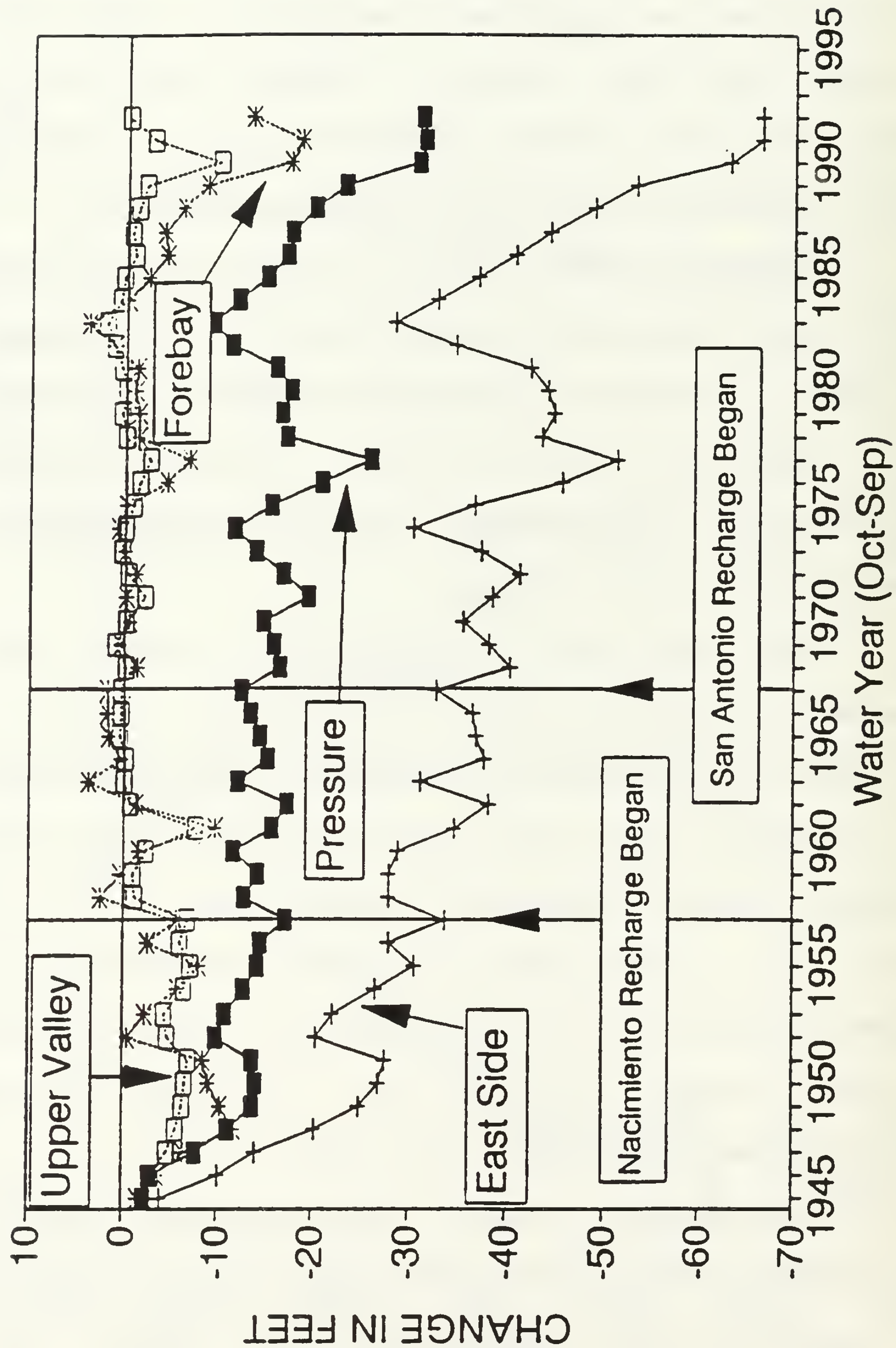


Figure 2-8. Annual Average Groundwater Levels in the Salinas Valley: 1945-1992 (Source: MCWRA, 1993)

TABLE 2-7. SALINAS VALLEY AVERAGE SEAWATER INTRUSION AND WATER BUDGET SUMMARY

HISTORICAL AVERAGE (1970-1992) (AF/YR)	
RECHARGE	
PERCOLATION	210,000
RECHARGE	244,000
BOUNDARY INFLOW*	44,000
TOTAL RECHARGE	498,000
DISCHARGE	
PUMPING	535,000
DIFFERENCE	(37,000)
STORAGE DECLINE	20,000
INTRUSION	17,000

*NOTE: Boundary Inflow = Total Boundary Inflow - Seawater Intrusion

TABLE 2-8. ESTIMATED GROUNDWATER DEFICIT IN THE SVGB: 1987-1992

Year	Groundwater Basin Deficit (ac-ft)
1991-1992	150,000
1990-1991	150,000
1989-1990	300,000
1988-1989	50,000
1987-1988	50,000

Furthermore, no one has put a social cost or economic value on the water that is being consumed from these reserves. By the

year 2020, urban sector demand alone is expected to increase by 139.9% over the 1980 usage.

2. Seawater Intrusion

The second problem the Salinas Valley groundwater basin faces is seawater (saltwater) intrusion along the coast. The current rate of seawater intrusion is 17,000 acre-feet per year. Seawater intrusion is caused by overdrafting in front of the seawater/freshwater interface in the Pressure Area. This causes the freshwater gradient to shift from its predominately westerly location to a more easterly location. This reversal has accelerated seawater intrusion into the 180 ft and 400 ft aquifers in the Pressure Area [Ref 1:p. 31]. Seawater intrusion is advancing at a rate that affects 575 surface acres per year above the 180-ft aquifer. Boyle Engineering estimates that the seawater interface is moving inland at an annual average rate of 800 ft per year. [Ref. 1 :p. 32] For the period 1970 to 1992, the Montgomery Watson Model report estimates that the average annual seawater intrusion rate into the Valley was 16,700 acre-feet; 11,300 acre-feet in the 180-ft aquifer, 4,600 acre-feet in the 400-foot aquifer, and 800 acre-feet in the deep aquifer. Figure 2-9 [Ref. 2:Fig. 5-14] shows the historical annual average seawater intrusion for each aquifer from 1970 to 1992.

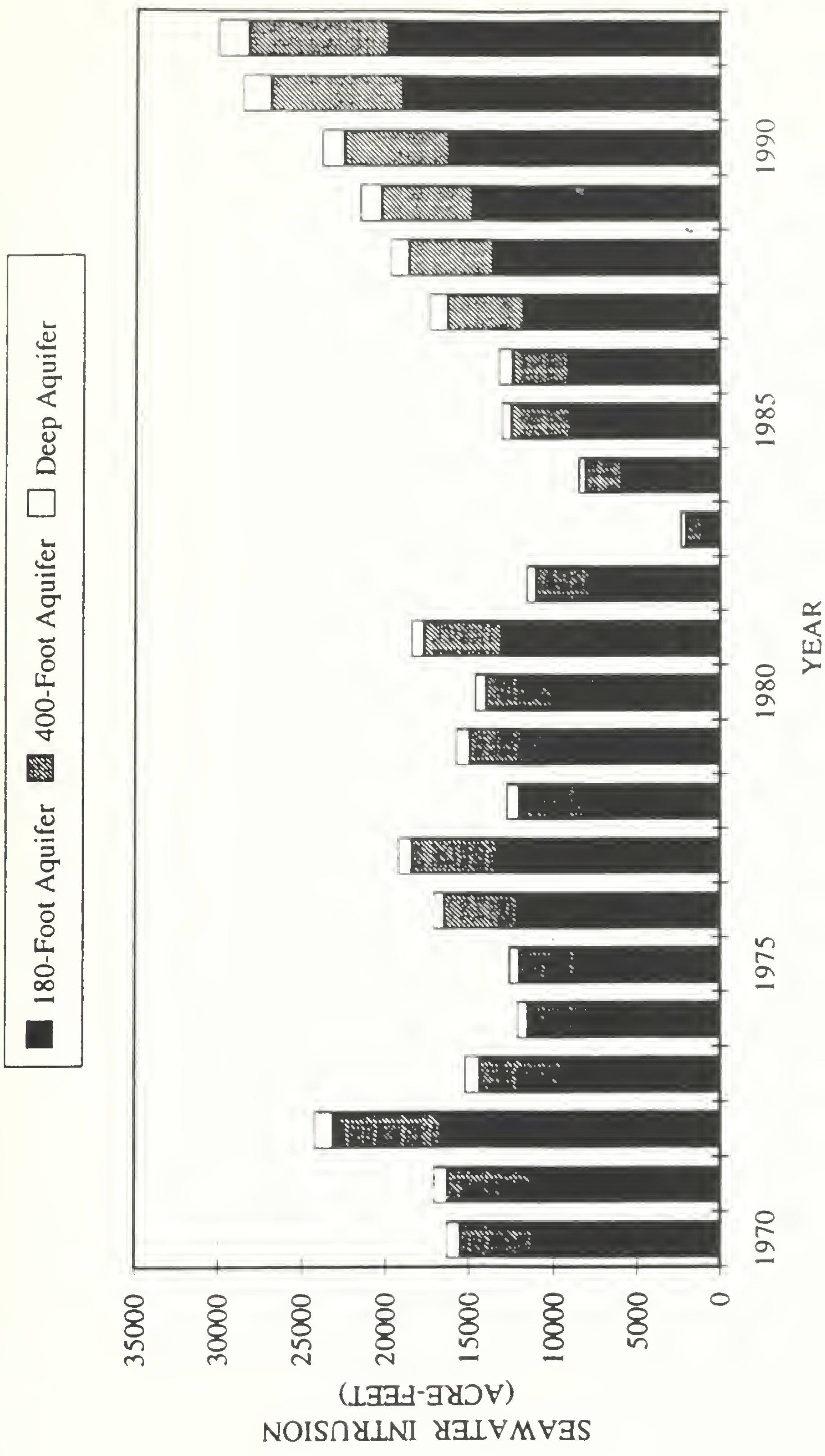


Figure 2-9. Historical Annual Average Seawater Intrusion

Seawater intrusion is slowly degrading the basin's groundwater quality. Seawater has a normal chloride concentration of 500mg per liter. When seawater mixes with groundwater, it slowly contaminants the aquifer with chloride. If the chloride concentration goes above 250 mg per liter, the water is no longer recommended for use as drinking water. If the chloride concentration goes above 350mg per liter, it is no longer fit for crop irrigation. Such water will damage the crops and reduce yields.

"In 1992, the MCWRA has measured chloride concentrations exceeding 500mg per liter in water from wells within three miles of the Salinas City limits" [Ref 1:p. 32]. The location of the seawater intrusion front poses an imminent threat to the municipal water supply for the City of Salinas. This has the potential to devastate the local economy. It may require the City to import fresh water from outlying areas, which is a very expensive solution to the problem of seawater intrusion.

3. Nitrate Contamination

The third problem in the groundwater basin is nitrate contamination. Nitrate contamination has had a significant effect on groundwater quality since the mid-1940's. This contamination corresponds to the introduction of inorganic nitrogen based fertilizers. These fertilizers have become heavily used in the Salinas Valley. It is believed that

nitrogen based fertilizer is the primary source of the nitrate contamination in the groundwater basin. The fertilizer's nitrogen migrates into the aquifer when irrigation water is over-applied. Other possible sources of nitrate contamination are: confined animal producing operations, individual septic tank waste disposal systems, and municipal and industrial run-off [Ref. 1:p. 37].

As of 1987, nitrate contamination has been found in the 400-ft aquifer. The MCWRA believes this is due to isolated point sources. The risk of further degradation from contaminated recharge sources is rising. Increasing nitrate concentrations have been found in the Upper Valley and Forebay areas in the 180-ft aquifer. In 1987, the mean nitrate concentration levels for the 180-ft aquifer in this region exceeded California's maximum contamination level (MCL) fornitrate in drinking water. (The current California MCL for nitrate is 45 mg per liter.) Also in 1987, forty-eight percent of all wells monitored by MCWRA in the unconfined hydrogeologic regions (Upper Valley and Forebay area) exceeded 90 mg per liter. This is twice the MCL for nitrate. In 1991, water from the 180-ft aquifer in the East Side and the Upper Valley areas also exceeded the MCL for nitrate. Table 2-9 [Ref. 1:p. 37] shows the mean nitrate concentrations and the percentage of wells that exceeded the California's MCL. These wells are monitored by MCWRA in the 180-ft aquifer.

TABLE 2-9. MEAN NITRATE CONCENTRATIONS AND THE PERCENTAGE OF WELLS THAT EXCEEDED CALIFORNIA'S MCL

1987	Mean mg/L	No. of Wells Tested	Percentage of Wells Exceeding 45 mg/L
Pressure	35.8	92	18
East Side	90.9	49	53
Forebay	49.6	42	38
Upper Valley	55.1	27	59
1991			
Pressure	30.5	72	18
East Side	57.5	57	18
Forebay	49.6	57	38
Upper Valley	73.5	22	68

In order to prevent these problems from worsening, it is crucial that local authorities restore the groundwater balance in the Salinas Valley ground water basin. This can be accomplished by providing new sources of fresh water, reducing the amount of water extracted, or a combination of both. The agency responsible for developing and implementing a plan to restore balance in the groundwater basin is the Monterey County Water Resource Agency (MCWRA).

F. MCWRA MISSION AND AUTHORITY

The MCWRA's basic mission is to manage and protect the Salinas Valley Ground Water Basin. This organization,

originally the Salinas Valley Flood Control and Water Conservation District, was transformed into the Monterey County Water Resources Agency when the State of California passed the Monterey County Water Resources Agency Act in 1990. This act broadly defines the agency's mission and powers. The MCWRA has delineated from this broad mission statement a list of goals, objectives and policies for the SVGB which are published in the Monterey County General Plan.

The MCWRA's mission as defined by the Monterey County Water Resources Agency Act is:

> ...to manage the groundwater in the Salinas Valley Groundwater Basin, and, in connection with such groundwater management activities, to conserve water in any manner, to prevent the waste or diminution of the water supply within the territory of the agency, and to prevent groundwater extractions which are determined to be harmful to the groundwater basin. The agency may further adopt,by ordinance, reasonable procedures, rules, and regulations to implement the Act, and may specify in any ordinance that a violation of the ordinance is an infraction.
> [Ref. MCWRA Ordinance No. 3717, Sect. 1.01.00 - Authority]

The MCWRA's mission is further explained by their published goals, objectives and policies, which are enumerated below:

1. Water Resources

5 GOAL: To conserve and enhance the water supplies in the county and adequately plan for the development and protection of these resources and their related resources for future generations.

5.1 OBJECTIVE: Protect and preserve watersheds and recharge areas, particularly those critical for the replenishment of reservoirs and aquifers.

5.1.2 POLICY: Land use and development shall be accomplished in a manner to minimize runoff and maintain groundwater recharge in vital water resource areas.

6 GOAL: To promote adequate, replenishable water supplies of suitable quality to meet the County's various needs.

6.1 OBJECTIVE: Eliminate long-term groundwater overdrafting in the County as soon as practicably possible.

6.1.1 POLICIES: Increased uses of groundwater shall be carefully managed, especially in areas known to have groundwater overdrafting.

6.1.2 Water conservation measures for all types of land uses shall be encouraged.

6.2 OBJECTIVE: Explore and implement measures to supply additional water to critically deficient areas.

6.2.1 POLICY: The County shall pursue development of suitable water supplies in keeping with broad conservation goals.

2. Water Quality

21 GOAL: To ensure that the County's water quality is protected and enhanced to meet all beneficial uses, including domestic, agricultural, industrial, recreational, and ecological.

21.1 OBJECTIVE: Protect and enhance surface and groundwater quality by implementing current adopted water quality programs and by continuing to evaluate new problems: develop new programs in accordance with the following policies by 1984.

21.1.1 POLICIES: The County shall establish growth policies which are integrated with the natural limitations of the County's surface and groundwater bodies to sustain acceptable quality.

21.1.2 The County shall assume an active role in initiating and supporting beneficial water programs that affect the County.

21.1.10 The County shall implement a program to prevent further seawater intrusion by developing a supplemental source of water for the North County. This may include water importation, water conservation, and waste water reclamation.

21.2 <u>OBJECTIVE</u>: Enhance the quality of water in the County by regulating the type, location, and intensity of land use, and grading operations.

3. Water Service

53 <u>GOAL</u>: To promote adequate water service for all County needs.

53.1 <u>OBJECTIVE</u>: Achieve a sustained level of adequate water services.

53.1.1 <u>POLICIES</u>: The County shall encourage coordination between those public water service providers drawing from a common water table to assure that the water table is not overdrawn.

53.1.2 The County shall, through the MCWRA and other appropriate agencies, assure adequate monitoring of wells in those areas experiencing rapid residential growth.

53.1.3 The County shall not allow water consuming development in areas which do not have proven adequate water supplies.

53.1.4 New development shall be required to connect to existing water services providers which are public utilities, where feasible.

53.1.5 Proliferation of wells, serving residential, commercial, and industrial uses, into common water tables shall be discouraged.

In order to accomplish this mission, the State of California recognizes that the MCWRA must have complete authority over the groundwater as well as the ability to raise funds to finance its operation. The State of California has established this authority through its constitution and public laws and acts giving the MCWRA legal authority to control all freshwater within the Salinas Valley and to raise funds through surcharges and/or fines on ordinance violations.

The following are California laws and acts which are pertinent to the MCWRA's ability to allocate water: they are presented to familiarize the reader with the MCWRA's current legal authority.

California Constitution, Article X, Section 5. - Conservation of water resources; restriction on riparian rights.

It is hereby declared that because of the conditions prevailing in this State the general welfare requires that the water resources of the State be put to beneficial use to the fullest extent of which they are capable, and that the waste, unreasonable use, or unreasonable method of use of water be prevented and that the conservation of such waters is to be exercised with a view to reasonable and beneficial use thereof in section shall be self-executing, and the Legislature may also enact laws in the furtherance of policy in this section contained.

California Constitution, Article X, Section 5. - Public Use; State Regulation and Control.

The use of all water now appropriated, or that may hereafter be appropriated, for sale, rental, or distribution, is hereby declared to be a public use, and subject to the regulation and control of the State, in the manner to be prescribed by law.

California Water Code, Section 100. - Beneficial Use of Water.

It is hereby declared that because of the conditions prevailing in the State the general welfare requires that the water resources of the State be put to beneficial use to the fullest extent of which they are capable, and that the waste or unreasonable use or unreasonable method of use of water be prevented, and that the conservation of such water is to be exercised with a view to the reasonable and beneficial use thereof in the interest of the people and for the public welfare...

California Water Code, Section 100.5 - Conformity with Local Custom; factor in determining reasonableness of the use, method of use, or method of diversion of water.

It is hereby declared to be the established policy of this State that conformity of a use, method of use, or method of diversion of water with local custom shall not be solely determinative of its reasonableness, but shall be considered as one factor to be weighed in the determination of the reasonableness of the use, or method of diversion of water, within the meaning of Section 2 of Article X of the California Constitution.

California Water Code, Section 102. - State Ownership of Water;

Right to Use.

All water within the State is the property of the people of the State, but the right to use the water may be acquired by appropriation in the manner provided by law.

California Water Code, Section 104. - State Use and Control of Water.

It is hereby declared that the people of the State have a paramount interest in the use of all the water of the State and that the State shall determine what water of the State, surface and underground, can be converted to public use or controlled for public protection.

California Water Code, Section 105. - Development for Public Benefit.

It is hereby declared that the protection of the public interest in the development of the water resources of the State is of vital concern to the people of the State and that the State shall determine in what way the water of the State, both surface and underground, should be developed for the greatest public benefit.

California Water Code, Section 106. - Highest Use of Water; Domestic; Irrigation.

It is hereby declared to be the established policy of this State that the use of water for domestic purposes is the highest use of water and that the next highest use is for irrigation.

California Water Code, Section 106.5. - Municipal Water Rights.

It is hereby declared to be the established policy of this State that the right of a municipality to acquire and hold rights to the use of water should be protected to the fullest extent necessary for existing and future uses, but that no municipality shall acquire or hold any right to waste waster, or to use water for other than municipal purposes, or to prevent the appropriation and application of water in excess of its reasonable and existing municipality to apply such water to municipal uses and when necessity therefore exists.

California Water Code, Section 109. - Efficient Use of Water; Encouragement of Voluntary Transfer of Water and Water rights.

a. The legislature hereby finds and declares that the growing water needs of the State require that use of water in an efficient manner and the efficient use of water requires certainty in the definition of property rights to the use of water and transferability of such rights. It is hereby declared to be the established policy of this State to facilitate the voluntary transfer of water and water rights where consistent with the public welfare of the place of export and the place of import.

b. The Legislature hereby directs the Department of Water Resources, the State Water Resources Control Board, and all other appropriate state agencies to encourage voluntary transfers of water and water rights, including, but not limited to, providing technical assistance to persons to identify and implement water conservation measures which will make additional water available for transfer.

G. STEPS TAKEN TO RESTORE THE WATER BALANCE

Following their published goals and objectives, the MCWRA intends to restore the Salinas Valley groundwater basin through a program incorporating development and construction to establish new water sources and water demand management. Any new water supply project will have to overcome environmental, economic, technical, social and political hurdles before actual design work can be started. Under the current approval process for developing a new water source, the most difficult approvals to obtain are from the Federal Environmental Protection Agency, Federal Fish & Wildlife Agency and State of California's Environmental office.

The National Environmental Policy Act (NEPA) and the California Environmental Quality Act (CEQA) require any new water supply construction project to comply with both acts. Under these acts, the project must demonstrate that it has no significant adverse impact or cumulative negative effect on the environment. The project's sponsors must document their resource use and mitigate any environmental impacts associated with the project. The sponsors must also document that all effective water conservation measures are currently in place, and that water demand still exceeds the current fresh water supplies. Thus, the MCWRA must establish a viable water conservation program before developing new water sources. An essential component of any water conservation plan is a water allocation program.

MCWRA, through its "Basin Management Plan (BMP) is currently determining the most economically viable way to develop new water sources and increase water storage efficiency in the groundwater basin. Capital cost estimates for the proposed projects range from $173.7 million to $327.5 million. These projects have estimated operating and maintenance costs ranging from $1.8 million to $5.2 million per year [Ref. 10:Table 5]. It will take a great deal of time for the political process to develop a consensus on environmental mitigation, cost sharing, technical feasibilities, and social and political issues for these projects.

Because of the time required to develop water supply projects, a water demand management program (alias the regulatory control system) appears to have become the critical element for reducing the near term imbalance in groundwater consumption. Water demand management will be necessary as long as water demand exceeds the recharge.

A water demand management program can vary from voluntary educational programs to direct intervention through rationing and strict governmental control. The MCWRA has chosen both a voluntary educational program and strict government controls. The controls impose upper pumping limits for the farm community and establish baseline reductions for the urban sectors.

At this time, the MCWRA has several voluntary educational programs to promote water conservation methods/programs and improve irrigation efficiency:

1. The Mobile Irrigation Laboratory program by MCWRA does free evaluations for local farmers and recommends how to improve their irrigation system's efficiency. This program was developed in 1990 as a cooperative, cost sharing program with the California Department of Water Resources. Since its development, the mobile lab program has conducted more than 100 evaluations in the Salinas Valley.

2. The California Irrigation Management Information System (CIMIS) is an integrated network of computerized weather stations located throughout California. This system estimates crop water requirements based on crop type and real time weather data. This program helps Salinas Valley farmers determine irrigation schedules and water budgets. This program is also co-funded by the California Department of Water Resources and MCWRA.

3. The Water Awareness Committee of Monterey County (WAC) provides a forum to inform community and industry leaders about water related issues and educational programs. It also provides MCWRA with critical feedback from industry and the community.

The second part of the MCWRA's water demand management program appears to have been established through several ordinances allowing the agency to monitor, control and set upper pumping limits for all commercial, industrial, agricultural and municipal wells in the Salinas Valley. These ordinances were passed during a period of three years and are presented in chronological order from oldest to newest.

On October 17, 1989, MCWRA Ordinance No. 3428 required registering and documenting water use for:

1. Water distribution systems with 50 or more service connections;

2. Industrial and commercial operations with water demand greater than or equal to 5 acre feet per year.

On March 5, 1991, MCWRA Ordinance No. 3523 required all agricultural water users in the Salinas Valley to file water conservation plans with a target reduction of 20 percent. Although filing the conservation plan is mandatory, the actual water conservation practices used are discretionary as long as the farmer achieves his reduction target. These conservation plans are required to include the following:

1. The location of the areas under cultivation and their acreage, with maps showing cultivated areas and all agricultural wells.

2. A signed and dated copy of the water conservation plan.

3. A schedule showing when during the year each chosen water conservation practice would be implemented.

4. The entire conservation plan had to be fully implemented by 1993.

On April 30, 1991, MCWRA Ordinance No. 3539 established regulations on water devices and uses such as:

1. Indoor and outdoor plumbing systems;

2. Decorative fountains;

3. Washing of automobiles or exterior surfaces;

4. Landscaping;

5. Water waste and indiscriminate, non-beneficial uses.

On February 2, 1993, MCWRA Ordinance No. 3663 affected all wells in Zone 2, 2A and 2B (i.e., the Pressure area where overdrafting is currently the greatest). It required wells having a discharge pipe with an inside diameter of three

inches or greater to install flowmeters and annually report pumping activity, water distribution and use. This ordinance gives MCWRA the ability to monitor and enforce MCWRA Ordinance No. 3523 and provides the potential to regulate pumping activities and charge a surcharge to create economic incentives to reduce water consumption. This ordinance also provides critical consumption data needed to develop a water demand management program.

On July 27, 1993, MCWRA Ordinance No. 3696 required all wells in subareas P-1, P-2, and E-1 (i.e., the East Side Area) to comply with the same requirements as the wells in MCWRA Zones 2, 2A and 2B.

On October 5, 1993, MCWRA enacted three major ordinances:

Ordinance No. 3717 changed the required compliance date for MCWRA Ordinance No. 3663 and No. 3696 to November 1, 1993 for zones 2, 2A and 2B, and February 15, 1994 for zones P-1, P-2, and E-1.

Ordinance No. 3735 revised MCWRA Ordinance No. 3720 effective on December 14, 1993. Ordinance No. 3720 established upper limits for pumping water from wells for agricultural irrigation in zone 2, 2A and 2B. It also established increasing penalties for violations of the ordinance. Penalties are based on an "increasing block rate structure" also known as a "Tier Penalty Rate Structure." This structure increases the amount of penalty in incremental steps or tiers based on how much is pumped over the established limit. The revision to Ordinance No. 3735 was enacted to increase the upper limit for certain type of crops.

Ordinance No. 3742 established charges for agricultural water from the Salinas Valley groundwater basin in zones 2, 2A and 2B, based on the quantity of water pumped. The Charges are incremental, increasing as the quantity of water pumped increases above the upper pumping limit. The revenue collected from this surcharge can only be used to develop and construct new water supplies to serve the

increasing demands for water in the basin. This surcharge is also based on an "increasing block rate structure." This water tax strategy is used to encourage water conservation.

On January 18, 1994, MCWRA Ordinance No. 3744 allowed MCWRA to control urban water consumption. The ordinance requires all urban water purveyors to submit urban water allocation and conservation plans for the territory within their jurisdiction. Suppliers are also required to reduce groundwater pumping by 15% per capita below the usage level in 1987 (last pre-drought year), or with a suitable alternative reduction approved by the Agency.

A variety of tax structures recognize that as the marginal cost of water increases (with the tax), demand will decrease. The tax structure must simply increase water prices as water consumption increases. There are three basic ways to accomplish this. One is a tier tax structure, as enacted by MCWRA. This structure reduces average and sometimes peak water consumption use.

The second tax scheme is known as the "lifeline tax structure" or "two tier tax structure." This structure ensures affordable water prices for necessary, minimum consumption. Water use in excess of the minimum requirements is taxed at a significantly higher rate. A "lifeline tax structure" reduces average water use [Ref. 1:p. 75].

The last structure is known as the "Scarcity Tax Structure." This structure is used when supplies are

diminishing. It passes the costs for developing new water supplies to current users. This structure uses a positive linear increase in price as supplies are depleted. Scarcity tax structures reduce average water use and discourage new service connections in water shortage areas or where water distribution systems are rapidly expanded [Ref. 1:p. 75].

The Scarcity Tax Structure will reduce groundwater pumping in all areas of the Salinas Valley groundwater basin. In turn, this will help bring the groundwater balance back into equilibrium, assuring a reliable groundwater source for the future. The tier tax rate structure will also provide the economic incentive for well owners to increase water use efficiency and reduce over-irrigation through cost awareness. This, in turn, reduces nitrate contamination caused by nitrogen based fertilizer.

The chronological development of the preceding ordinances indicates the framework of MCWRA's most likely future allocation plan. It is likely to be based on demand management and will incorporate two methods of controlling water allocation: maximum consumption and taxation.

The maximum consumption approach limits the amount of groundwater that certain sectors of society can extract. This approach is consistent with MCWRA Ordinances No. 3744 and 3720. These pumping limits will likely be established at a level that balances total annual groundwater extraction and annual recharge volumes for the groundwater basin.

Continuing taxation with upper pumping limits provides the agency a new revenue stream with which to finance new water sources and operate the allocation program. The tax approach also encourages increased water efficiency and reduces water use through economic incentives; the upper pumping limits assures the groundwater cycle is always is balanced. The combined effect will slowly restore the Salinas Valley aquifer to its natural groundwater storage capacity. This ability to tax was established by MCWRA Ordinance No. 3742.

In Chapter V, this inferred water demand management allocation plan will be compared to a proposed privatization allocation plan designed for the Salinas Valley groundwater basin. The comparison will indicate which program would be more economically efficient at reducing water use for a small sample of representatives from the industrial, urban and agricultural sectors of Salinas Valley. The following chapter will review literature on natural resource allocation and explore the advantages and disadvantages of the various methods of allocating natural resources.

III. BACKGROUND ON THREE METHODS OF ALLOCATING GROUNDWATER

"What is common to many is taken least care of, for all men have greater regard for what is their own than for what they possess in common with others." Aristotle

Throughout the country, local municipalities have been increasing their interest in using economic incentives through privatization to efficiently use or conserve their public goods/natural resources. Privatization is the process of taking an "Open Access Resource" (classification of public good or natural resource), breaking it down into definable parcels or units and transferring or selling these property units to private or public organizations. Each private or public organization will have the right to use, control and obtain benefit from this resource as well as the ability to transfer these rights to another party. Privatization has four basic behavioral implications that occur once private ownership and transferability have been established:

1. Private owners can gain by employing this resource in ways that are beneficial to others, or can bear the opportunity costs of ignoring these economic opportunities.

2. Owners have strong incentives to properly care for and maintain this resource in order to preserve its value.

3. Owners have strong economic motives to conserve for the future when the resource is expected to increase sufficiently in value.

4. Accountability is established for the damage done to others by the owner misusing his resource.

The key element of privatization is transferring property rights to ensure that individuals will consider the opportunity costs of their actions. For example:

> As long as individuals are free to buy and sell water rights, market prices will emerge, making owners aware of the cost of wasting water. If rights are not transferable, however, the fact that water has more valuable alternative uses will make little difference; the owner will not be able to sell the rights and capitalize on these higher valued uses. [Ref. 11:p. 227]

The two areas receiving the most academic attention are tradeable water rights and air pollution discharge permits. Working theories in these markets provide the fundamental foundation for studying the privatized transferable water rights in the Salinas Valley groundwater basin. Two fundamental principles are required to obtain allocation efficiency through privatization: definable and enforceable property rights, and the ability to trade these rights.

A. PROPERTY RIGHTS

The first principle of definable and enforceable property rights is that the individual will take into account the opportunity costs of his actions. As long as individuals are free to buy and sell water rights, market prices will emerge, making the owners intensely aware of the economic costs of their actions.

Definable and enforceable property rights are a prerequisite for economic efficiency. Under the principle of economic

efficiency, a transaction is desirable if it generates benefits in excess of both the private costs borne by the consenting parties as well as the external cost imposed on nonconsenting secondary parties. Externalities occur when a transaction takes place between two parties and the transaction or market price does not reflect the true benefit and costs to the two parties and society. This externality can have two effects: external benefit or external cost. External benefits occur when the transaction has a beneficial effect on the welfare of a nonpaying second party or society. External costs result when the transaction harms a nonpaying second party or society.

If property rights are not definable or enforceable, the resource is an "Open Access Resource, which is defined as a resource to which access is unrestricted, (and no one) has the right to exclude others from using (this) resource. Overuse and abuse of such a resource is typical." [Ref. 15:p. 527] This is exemplified in the article "The Tragedy of the Commons" by Garrett Hardin [Ref. 12:pp. 88-91]. Hardin graphically illustrates numerous examples of this in the public goods/natural resources area, i.e., North African herdsmen, fisheries off the New England coast, Hutterite communities in the northwestern United States (when their community population exceeds 150), and the recent Federal Savings and Loan Insurance Corporation policy. In all these

examples, the natural resource or public good was exploited to the point of devastation.

The most visible of these examples was photographed in 1974. A satellite photo of Northern Africa showed an irregular dark patch, 390 square miles in area, with a green spot in the center. This green spot was fenced green pasture. Outside of it, the vegetation had been devastated. The fenced area was private property. The owner practiced proper land management. The land was subdivided into five areas and the herd was rotated to a new area each year. This left the remaining areas fallow for four years, giving the land adequate time to recover from grazing.

The land outside the fence area was public grazing land open to nomads and herdsman. These nomads and herdsman increased the size of their herds, but the grazing capacity of this land remained constant. The herds slowly exceeded "the natural carrying capacity of their environment, soil was compacted and eroded, and 'weedy' plants, unfit for cattle consumption, replaced the original plants. Many cattle died and as a consequence, so did humans." [Ref. 12:p. 88] Thus, the private land demonstrated that private property with defined ownership encourages owners to consider the opportunity costs of past, current and future actions.

James Madison, in 1788, explained what happened best: "If men were angels, no Government would be necessary. That is, if all men were angels. But in a world in which all resources

are limited, a single non-angel can spoil the common environment for all." [Ref. 12:p. 89]

The spoilage process comes in two stages. First, the non-angel gains from his competitive advantage over the angels (pursuing his own interest at the expense of others). Then, as the once noble angels realize that they are being left behind, some of them renounce their angelic behavior. They try to get their share out of the commons before competitors do [Ref. 12:p. 89]. Thus, resource which is an "Open Access Resource" will eventually be depleted and ruined.

B. FREE TRADE

The second principle of privatization is the ability to freely trade property rights. This encourages conservation of limited resources. Industries with a comparative economic advantage in conserving a resource can sell their excess to other industries, which presumably have a higher conservation cost.

If resource owners choose to ignore the opportunity to conserve and sell the excess resource, they will incur the opportunity cost of the foregone profits. This provides an economic incentive for conservation.

Both buyer and seller gain through trading. Buyers receive additional resources at a lower cost than if they had to conserve or provide the additional resource themselves. The sellers profit by selling the resource at a higher price

than its value to them. Trade produces a win-win result in that both buyer and seller gain through the transaction. Thus, society generally gains as a whole, as demonstrated by modern western society.

Trade also provides incentives for industry to develop or improve existing conservation technology. Resource buyers have incentives to investigate ways to reduce their resource cost by developing new conservation technologies or methods. Sellers have incentives to improve their existing conservation methods to increase their profits. Through trade, both buyer and seller have incentives to use resources efficiently and allow society to use the resource for the most valuable alternative uses; using resources inefficiently would cause a future economic loss to society if trade were not allowed.

C. NEGATIVE EXTERNALITIES OF THE SALINAS VALLEY GROUNDWATER BASIN

When using a natural resource or public good involves negative externalities, the government should take action to eliminate the externality if three conditions are satisfied:

1. The cost of public sector involvement is less than the social and economic cost of the externality.

2. The free market cannot reasonably adjust its market price to account for the externalities.

3. Public sector involvement does not create a second negative externality which is more serious than the first.

1. Salinas Valley Groundwater Basin

The Salinas Valley is experiencing a negative externality related to water use because water is currently treated as an open resource. This has led to overpumping in the SVGB. The State of California has attempted to address this externality via letter of direction to the MCWRA [Ref. 30]. The State of California Water Resources Control Board directed the local governments in the Salinas Valley to develop an allocation program to eliminate over-drafting and prevent further seawater intrusion into the aquifer. The Monterey County Water Resources Agency was tasked to develop this allocation plan.

This negative externality results because the individual user's cost of pumping water out of the aquifer does not reflect the true cost of water. The true cost of water (marginal social cost (MSC)) is composed of two parts: the marginal cost of production (MC) and the marginal external cost of overdrafting the aquifer (MEC). In equation form, this can be stated as follows (MSC = MC + MEC) [Ref. 13:p. 641]). The marginal cost of production in the Salinas Valley includes the following costs:

1. Site development and well drilling.
2. Labor, fuel/electricity, and pumping equipment cost.

3. Construction and operational costs of the Nacimiento and San Antonio Reservoirs. These reservoirs are used to increase the aquifer's recharge efficiency.[10]

The marginal external cost of overdrafting the aquifer involve the following costs:

1. Cost of seawater intrusion absorbed by the coastal communities and coastal farmers.

2. Increased pumping cost because of the lowered water table in the basin.

3. Opportunity cost of depleting the aquifer reserve.

4. Cost of the irreversible damage to the aquifer's holding capacity as the semiconsolidated sediments are compacted. "When the water level is lowered, the sediments undergo irreversible compaction, squeezing out water from their interstices" [Ref. 14:p. 229].

Currently, well owners in the Salinas Valley pay directly for both the capital and operating costs of their wells. In addition, well owners in Zone 2A help pay for the capital and operating costs of the two reservoirs in the southern part of the Monterey County. These costs are allocated on the basis of the type of crop grown and number of acres of crop land, not on the amount of water the individual pumps. This cost allocation strategy gives a misdirected incentive to the individual well owner.

For example, suppose two identical farms (farm A, farm B) in Zone 2A are located side-by-side and their tax contributions for the reservoirs are the same. Because these

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[10]The construction cost for the two reservoirs was $19.9 million. ($7 million for the Nacimiento Reservoir in 1956 and $12.9 million for the San Antonio Reservoir in 1963).

contributions are based on crop type and acreage, not water pumped, Farmer A realizes that his marginal cost per gallon of water consumed is zero. No matter how much water is pumped, Farmer A's costs do not change.

Suppose Farmer A's reservoir tax is $1000 per year. Under his initial growing plan, Farmer A's water consumption was 100,000 gals per year. Farmer A decides to adopt a more water intensive growing plan which substitutes water for some fertilizer and labor. Under the new growing plan, water consumption will be 125,000 gals per year. However, Farmer A's total cost decreases because fertilizer and labor cost decrease while water costs remain the same. Farmer B, who is using a less water intensive growing plan, realizes that Farmer A has an advantage with respect to production costs. To be competitive, Farmer B switches to a more water intensive growing plan. Both farmers are equally competitive, but water use has now increased by 25%.

Well owners in the valley do not pay directly or indirectly for the marginal external cost of overdrafting. This negative externality was not even considered until the 1940s, when the coastal communities and farmers started to feel the financial impact of overdrafting. Overdrafting has increased costs due to seawater intrusion and the lowered water table. The economic and social cost of seawater intrusion and the lowered water table could be calculated and charged to well owners. But the economic and social costs of

depleting the reserve water in dead storage and the irreversible damage to the aquifer's holding capacity cannot be estimated with any significant accuracy.

2. Responses to Negative Externalities

The California Water Resources Control Board (SWRCB) directed the MCWRA to internalize these negative externalities by developing an allocation plan which reduces and ultimately eliminates the aquifer overdrafting. There are four basic economic procedures to resolve this situation: regulatory systems of control, taxation, privatization, and a hybrid mix of two or more of these three procedures. The primary differences between these procedures are the amount of government involvement and the resulting level of economic efficiency. Each of these procedures requires determining a maximum sustained water yield and implementing local legislative procedures to monitor and enforce the program.

D. MAXIMUM SUSTAINED YIELD

According to Mandel and Schiftan, the definition of maximum sustained yield is the maximum rate at which a resource can continuously be extracted for 100 years without causing unacceptable consequences. [Ref. 14:p. 231] In hydrological terms, the maximum sustained yield is based on the following six conditions:

1. The safe yield refers to the supply capacity of the entire groundwater system, not to limitations caused by

inappropriate location of wells or by the excessive concentration of many wells in a part of the aquifer.

2. The first undesired but unavoidable effect of groundwater extraction is a lowered water level that may, in its turn, induce other unwanted discharges in thin phreatic aquifers, intrusion of saline water from the ocean, soil subsidence, reduction of the dry weather flow in the rivers and springs, and deterioration of water quality because of the access of air to oxidizable compounds in the stratigraphic column [Ref. 14:p. 232]. To determine if the effect is truly unacceptable, or merely a nuisance in terms of environmental, economic, social or political implications requires social and moral judgement.

3. Adverse effects can be defined as the new negative effects occurring if the water level drops below current levels, or the negative effects that have occurred since overdrafting reduced the water level below its historical natural level. Again, this issue of what water level to use will have to be resolved by social and moral judgement.

4. For sustained yield exploitation, two hydrologic conditions must be met: A quasi-steady state was defined by the preceding factors 1, 2, 3. All other unwanted effects, including those that take a very long time to materialize, must be kept within acceptable limits. Therefore, the maximum rate of exploitation, commensurate with the first factor must equal the average annual replenishment rate [Ref. 14:p. 232].

5. The climate and soil coverage of the area will remain relatively unchanged, and man-made pollution is not expected to enter the hydrologic cycle.

6. Under the above factors, the aquifer may be regarded as a simple system with only three major system variables: annual groundwater extraction, area of distribution of the groundwater extraction, and water levels. Minor system variables, such as the depths of boreholes, and monthly pumping schedules are neglected [Ref. 14:p. 232].

Once these factors have been determined, the maximum sustained yield can be estimated by the following six step procedure:

1. Determine the average annual replenishment rate for the groundwater basin.

2. Identify the most stringent constraint based on the conditions in factors 2 & 3 stated earlier.

3. Determine the quantitative relationship between water level elevations and the occurrence of the primary adverse effect.

4. Locate the key areas of the aquifer and define minimal water levels that are acceptable to society.

5. Compute the steady-state rate of groundwater leaving the groundwater basin based on the preceding assumptions.

6. Maximum sustained yield is equal to the difference between average annual replenishment rate (step 1) and the outflow rate (Step 5).

E. LEGAL AUTHORITY

The Monterey County Water Resources Agency Act per Stats. 1990, Chap. 1159, gives the Monterey County Water Resources Agency (MCWRA) jurisdiction over all matters pertaining to water within the entire area of the County of Monterey, including both incorporated and unincorporated areas. Under this act,

> the agency is authorized to conserve water in any manner, to prevent the waste or diminution of the water supply within the territory of the Agency, to conserve water for the present and future use within the territory of the Agency, and to prevent groundwater extractions which are determined to be harmful to the groundwater basin. The Agency may further adopt, by ordinance, reasonable procedures, rules, and regulations to implement the act, and may specify in any ordinance that a violation of the ordinance is an infraction. The Agency has power to perform all other acts necessary or proper to accomplish the purposes of the act.

The West Water Code Appendix, Chapter 52, Section 52-9 (d6) also confers the MCWRA authority to give water rights to individuals. The authority of the State to issue water rights and transfer these rights to MCWRA through the West Water Code is established under the California State Constitution, Article 11, Section 101. This article gives the state sole ownership of all groundwater and the authority to control, transfer and determine what the "reasonable use is" for fresh water. This legal position is supported by "Reasonable Use Doctrine," stating that landowners over the aquifer have coequal rights to the groundwater, subject to reasonableness. Reasonableness is determine by judicial judgement based on the demand and how the particular landowners use the water.

This preceding act and statue gives the Monterey County Water Resource Agency the authority to implement the four types of allocation plans (regulatory system of control, taxation, privatization or hybrid mix of two or more of the prior procedures) to control and eliminate overdrafting in the Salinas Valley Groundwater Basin.

The ground work for establishing any one of these three types of allocation plans has been established by the following three ordinances.

MCWRA Ordinance No. 3717: establishes the precedent to monitor water extraction activity and use this information for enforcement and for assessing fees based on water use. This is an essential element for all allocation plans.

MCWRA Ordinance No. 3663: establishes the requirement for water extractors who are within zones 2, 2A, or 2B, and

have a discharge pipe with an inside diameter of at least 3 inches to report water use information on an annual basis, and to install flowmeters on their groundwater extraction facilities and service connections. The flowmeters will

> allow the agency to allocate the costs of water management activities in the Salinas Valley Groundwater Basin and any new water projects for the basin, based upon actual water use. Fees or assessments based on water use will only be used for the production and delivery of water and for water management activities, including, but not limited to, the development and implementation of water allocation plans, water conservation plans, and water supply projects. (Ref. MCWRA Ordinance No. 3717, p. 4, para E)

A second ordinance creates a precedent for establishing and banking water credits[11] and setting upper pumping limits for certain water uses and industries. The ability to issue water credits and set upper pumping limits is essential for establishing a regulatory, or privatization allocation plan.

MCWRA Ordinance No. 3720: establishes upper limits for pumping water from wells for agricultural irrigation uses in MCWRA zones 2, 2A, and 2B. The limit is based upon well location and type of crops to be irrigated from the well. The ordinance allows a credit for savings made by a water supplier to be applied to excess usage on other lands by the same water supplier within the same sub-basin. This credit can be carried over one reporting year and is non-transferable.

Finally, **MCWRA Ordinance No. 3742:** establishes a precedent for taxing water that is extracted from private wells. This is an essential element to instituting a taxation allocation plan. Specifically, it establishes charges to be levied on agricultural water suppliers pumping groundwater from zones 2, 2A, and 2B of the Salinas Valley Groundwater basin based on the quantities

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[11]If an agricultural water supplier pumps less than the quantity allowed for one farming unit served by that water supplier, then the water supplier may, for one reporting year, exceed the pumping limit for other farming units supplied by that water supplier (whether or not from the same extraction facility) in the same sub-basin where the savings accrued. (Ref. MCWRA Ordinance No. 3720, para 1.02.30)

of water pumped. One of the purposes stated in the ordinance is to "bring about a reduction in pumping by individual growers, to the maximum extent feasible for each grower, and to reduce significantly the overall pumping from the Salinas Valley Groundwater Basin. [Ref. MCWRA Ordinance No. 3742, p. 3, sect. 1.01.20]

These ordinances have provided the framework for establishing an allocation program that could be based on any of the four allocation methods discussed previously. The allocation plan that will eventually be adopted by the MCWRA will be determined in the political arena. The merits of each allocation method for the Salinas Valley Groundwater Basin are discussed below.

F. REGULATORY CONTROL SYSTEM

In a regulatory control system (i.e., setting maximum consumption standards), a government regulatory agency determines the maximum sustained yield (MSY). Once MSY is determined, the agency establishes and enforces the maximum sustained consumption limits (i.e., daily, monthly, annual) for each individual consumer or class of consumer or industry. Consumers who are unable or refuse to limit their consumption to these standards are in noncompliance. Such consumers are subject to a fine or termination of their rights to consume water. Typically these limits are reviewed and approved on an annual basis through a public hearing process.

1. **Advantages of Regulatory Control**

The following are the basic advantages of this allocation method:

1. Historically, a regulatory system of control is the most widely used water allocation method in the United States. Therefore, agencies have a great deal of historical data and experience in implementing this type of program. They also know about the negative effects such programs can create.

2. This control system is relatively easy to implement. For example, it took the following three ordinances for the MCWRA to establish this type of program: MCWRA Ordinances No. 3720 and No. 3735 instituting upper pumping limits for agricultural use, and MCWRA Ordinance No. 3744 instituting upper pumping limits for cities and urban water use based on a 15 percent reduction using 1987 as a baseline.

3. This control system is relatively easy to monitor and enforce. A monitoring program has been established through MCWRA Ordinance No. 3717. Under this ordinance, all wells that have a 3" inside diameter or larger discharge pipe must install flowmeters and report water use information on an annual basis.

4. This control system can be enforced through penalty system, as established by MCWRA Ordinance No. 3742. This ordinance instituted a three tier penalty system for exceeding the agricultural upper pumping limits. The charges are levied against violators based on the amount of water by which an individual has exceeded the limit. Currently, there is no penalty system for cities and urban water districts. A limited number of violations are being reported by violators themselves. MCWRA has not developed an enforcement and verification program for the annual water use reporting process.

5. This regulatory control system would be designed to have a neutral financial impact on MCWRA. The revenue generated from penalty charges are expected to offset the annual cost of the enforcement and verification program. The metering program cost is borne by the individual well owners.

6. The county government would retain complete legal authority over groundwater use in the basin.

7. Upper pumping limits create an economic incentive for water users to invest in sufficient conservation methods and technology to meet the imposed upper pumping limit. This increases the efficiency with which they use and recover water.

2. Disadvantages of Regulatory Control

The following are the basic disadvantages of this allocation method:

1. The costs of reducing water consumption vary greatly among different consumers. Some consumers can reduce their consumption more cheaply than others. The regulatory system of control fails to use this fact to maximize water reduction per dollar of expenditure on conservation. Less water is conserved per dollar than under the taxation and privatization allocation methods. This increases society's conservation cost. From the economic standpoint, a regulatory control system is the least efficient of the three allocation methods.

2. There are minimal economic incentives for consumers to reduce their groundwater pumping below the imposed upper pumping limit.

3. Economic inefficiencies are created by the political process for several reasons:

   a. *Voter ignorance.* The populace is generally unable to fully recognize all the costs and benefits. Some of the costs are concealed by the complicated legislative actions. Voter ignorance can be explained by the concept of "rational ignorance." [Ref. 15:p. 94] Individuals lack incentives to fully inform themselves on issues because they do not recognize individual economic gains from doing so and they believe that their one vote is unlikely to be decisive.

   b. *The power of special interest groups.* Special interest groups frequently receive consideration and benefits derived from vote-conscious politicians. Politicians know that special legislation generally imposes a small cost on individuals in society. However, political favor to special interest groups can yield a great deal of personal political gain for that politician. This political gain is in the form of voting blocks and financial contributions provided by these

groups. Politicians also realize that the general public doesn't have the time or interest to examine legislative actions thoroughly, especially complex ones. Therefore, politicians will often take a chance and pass legislation that favors a particular interest group, hoping the public will not find out. In the end, the net cost to society will generally exceed the benefit to the special interest group. [Ref. 15:p. 96]

c. *Shortsightedness of politicians.* Economic inefficiencies result from political bias "in favor of proposals yielding clearly defined current benefits in exchange for difficult to identify future costs and against proposals with clearly identifiable current costs yielding less concrete and less obvious future benefits." [Ref. 15:p. 97]

G. TAXATION ALLOCATION SYSTEM

The taxation allocation system (consumption fee) consists of a surcharge levied on each gallon or acre-foot of water pumped from an individual well. A surcharge is theoretically set equal to the marginal cost of the negative externalities associated with overdrafting the aquifer. However, this cost is extremely difficult to estimate. It is virtually impossible to determine either the cost of depleting the aquifer's reserve water stock in dead storage or the cost of the irreversible damaged done to the aquifer's holding capacity as the semiconsolidated sediments in it are compacted.

Most government regulatory agencies will set their surcharge equal to maximum sustained yield price (P*) per unit minus water extraction cost per unit (MC). [Ref. 13:p. 640]

The maximum sustained yield price is the price level which reduces the pumping activity to the maximum sustained yield.

To calculate this price, the agency needs to determine the groundwater's price elasticity of demand (EP). This measures the percentage change in the quantity demanded resulting from a percentage change in price. This data can be determined through historical pricing and pumping data, if available, or estimated by empirical methods.

In addition to the price elasticity of demand (EP), the agency needs to determine: the current amount of water being extracted from the aquifer (Q1), the marginal extraction cost per unit (P1) and the maximum sustained yield for the aquifer (Q*). The price (P*) can be derived from the following equation:

$$EP = \frac{(Q^{*}-Q1)/Q1}{(P^{*}-P1)/P1}.$$

See Figure 3-1 [Ref. 13:p. 641]

EP = Price Elasticity of Demand

Q* = Maximum Sustained Yield

Q1 = Current Amount of Water Being Extracted from the Aquifer

P* = Price

P1 = Marginal Extraction Cost per Unit

In reality, however, setting the tax rate will probably be an iterative process, just as it would be for setting thresholds for a regulatory system of control. The tax rate would be adjusted until overdrafting stops. This would be

determined through hydrological field measurements of the SVGB. Thus, a lower degree of precision for the computational requirements would be acceptable under this type of iterative tax program.

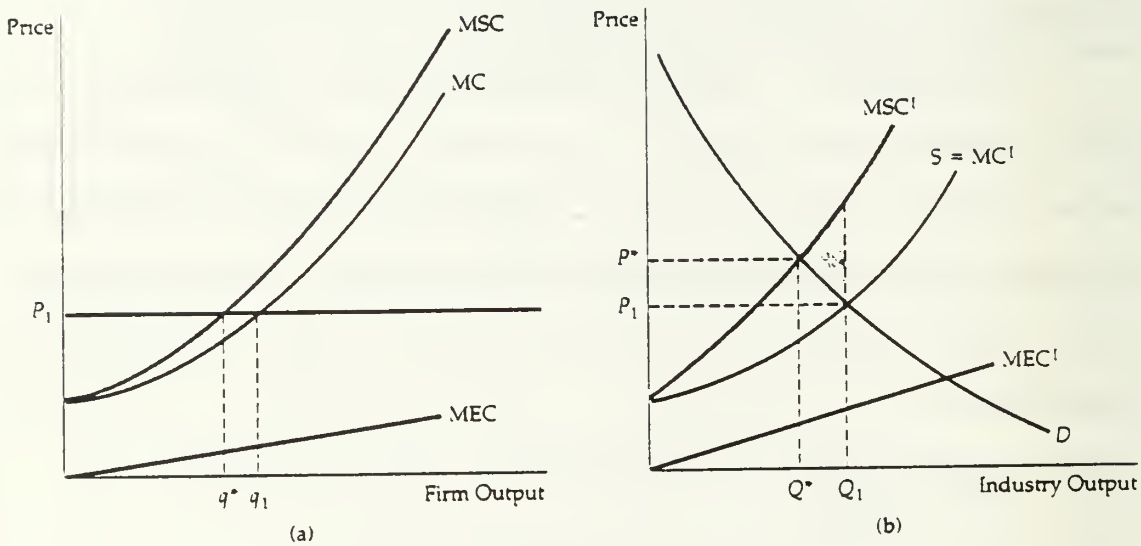

Figure 3-1. External Costs

When there are negative externalities, marginal social costs MSC are higher than marginal private costs MC. The difference is the marginal external cost MEC. In part (a), a profit-maximizing firm produces at q_1, where price is equal to MC. The efficient output is q^*, at which price equals MSC. In part (b), the industry competitive output is Q_1, at the intersection of industry supply, MC^1, and demand D. However, the efficient output Q^* is lower, at the intersection of demand and marginal social cost MSC^1.

The revenue collected from the surcharge can be used to offset the cost of the program for verifying the reports of annual water use. Any remaining revenue could be used to develop new water supplies to serve the community or to subsidize additional conservation investments.

1. Advantages of Taxation

The following are the basic advantages of this allocation method:

1. This allocation system promotes several economic incentives which increases allocative efficiency.

   a. Per unit surcharges increase the economic incentive to grow or make products that require less water per dollar of gross revenue. Surcharges increase production costs, thus lowering profit margins for water-intensive products.

   b. Per unit surcharges promote water conserving production methods and control technology. Industry will invest in these programs up to the point where the marginal cost of the investment is equal to the cost of the surcharge.

   c. Per unit surcharges provide economic incentives to develop new water conservation, application and recovery technologies.

2. The taxation allocation system has a positive financial impact on MCWRA, assuming that the revenue generated from surcharges will offset the verification and enforcement program costs. If sufficient excess funds are available, new water sources could be developed for the valley and additional conservation investments can be made.

3. The taxation allocation system is relatively easy to monitor and enforce. A monitoring program has been established by MCWRA Ordinance No. 3717. Also, MCWRA Ordinance No. 3742 sets a precedent for the MCWRA to assess fines.

4. This allocation system is relatively easy to implement. MCWRA has established a legal precedent through MCWRA

Ordinance No. 3742 to levy surcharges against well owners in agricultural pumping in zones 2, 2A and 2B.

5. This allocation system achieves greater economic efficiency compared to the regulatory system of control. Surcharges can achieve the same level of water reduction, but at a lower cost to society. See Figure 3-2 [Ref. 13:p. 646] All water users will increase conservation until the cost of conserving one more unit exceeds the cost of the tax. Thus, water users with lower conservation costs will conserve more. Under a regulatory system, all water users must conserve up to their maximum pumping limit irregardless of their conservation costs.

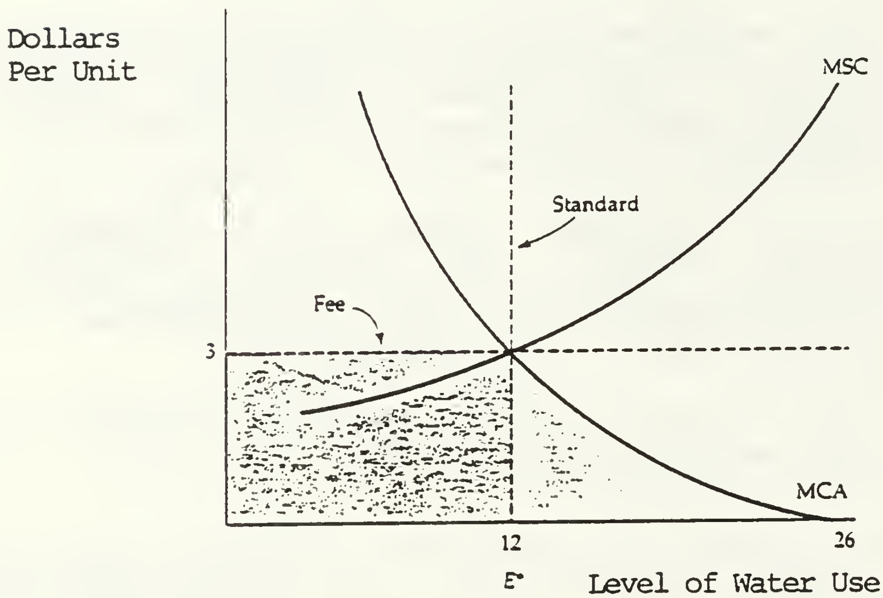

Figure 3-2. Standards and Fees

The efficient level of conservation at E* can be achieved either through water use fee or a water use standard. Facing a fee of $3.00 per unit of water use, a firm reduces water use up to the point at which the fee is equal to the marginal benefit. The same level of water conservation can be achieved with a standard that limits water use to 12 units. [Ref. 13:p. 646]

2. Disadvantages of Taxation

The following are the basic disadvantages of this allocation method:

1. Economic inefficiencies can be generated through the political process by giving special interest groups special legislation or subsidies as discussed under regulatory control system.

2. It is politically difficult to change the surcharge. Changes in the surcharge would become necessary whenever the surcharge fails to elicit the predicted water consumption. This could result from an error in determining the price elasticity of demand or a change in the recharge rate for the basin due to prolonged drought conditions. It is also politically difficult to establish the surcharge in the first place. For example, several special interest groups have filed suits intended to stop MCWRA from implementing a surcharge on agricultural water users in zones 2, 2A and 2B. [Ref. 16]

H. FREE MARKET (PRIVATIZATION) ALLOCATION SYSTEM

A free market allocation system (transferable consumption rights) involves taking an open access resource, dividing it into definable units and transferring or selling these units to private or public organizations. Each private or public organization would then have the right to use, control and obtain benefit from their units, or transfer (sell) these units to another party.

The method of initially allocating this resource can vary, from granting rights based on historical groundwater consumption patterns to the government selling these rights in an auction.

> It is one of the desirable properties of an appropriately designed transferable rights system that the ultimate allocation of these rights among private parties will be cost-effective regardless of their initial allocation as long as the rights are traded in a free competitive market. [Ref. 17:p. 251]

According to current economic understanding, free market allocation systems are the most efficient method for allocating limited valuable resources. [Ref. 11:p. 248, and Ref. 15:p. 534, and Ref. 13:p. 650]

1. Advantages of Free Market Program

The following are the basic economic advantages accepted by the general economic community for this type of allocation method:

1. A system of transferable consumption rights has the potential for achieving greater water conservation and more efficient allocation of groundwater at a substantially lower cost than would have been achieved with taxation or with a regulatory control system. This statement is supported by several pieces of evidence, including studies of transferable discharge permits for air pollution in the United States [Ref. 17:p. 242], the success of Great Britain's privatization program for inland rivers and streams in England and Scotland [Ref. 12:p. 443, and Ref. 18:p. 83] and the privatization of the Tehachappi groundwater basin [Ref. 11:pp. 242-248].

2. There are at least two potential savings to society and/or the individual which do not occur under the regulatory allocation method:

   a. Greater efficiency in water allocation can be achieved by trading water shares within a common industry than would be achieved by the regulation allocation method. A typical example of this would be the agricultural industry. Under a regulatory control system, the government would establish upper pumping limits for agricultural use. These restrictions could force the industry to quit growing water intensive crops even though these crops could be produced profitably even if growers

bear the true marginal cost of water. Society would lose the economic value added by this crop.

Under the privatization program, this loss to society would not have taken place. Farmers who have a distinct competitive advantage growing water intensive crops due to soil conditions, climate, farming techniques, or other factors could continue to do so by buying additional water from farmers who are now growing non-water intensive crops.

b. Greater allocation efficiency can be achieved from trading water shares across different industries than would be achieved by the regulation allocation method. Similar economic gain for society can be generated by trading water between industries as can be generated by trading water within an industry. This economic gain for society will only occur if the industries have different costs of reducing water consumption and water is sold at its true value. This transaction allows industries to lower their production cost by purchasing water more cheaply than the cost of conservation. This transaction reduces the social cost of water conservation per unit. Regulatory control systems do not have the inherent ability to allocate water conservation efforts and costs evenly across differing industries.

The preceding theoretical advantages in allocation efficiency of a free market (privatization) allocation system were realized by the Tehachappi-Cummings Water District when the granted private parties flow rights. This community reduced imported water use for agricultural by 46% and for municipal and industrial use by 32% over a five year period beginning in 1975. [Ref. 11:p. 242]

3. A profit incentive is provided for industries to lower their costs of conserving water and become more water efficient in order to sell their excess water to industries where it is more expensive to reduce water consumption. This new revenue source also provides the catalyst and funding for renewed water conservation research application and recovery.

4. The system allows the free market to allocate current and future groundwater use based on the most valuable water use at that time. Industry or business can simply purchase its water requirements from private parties and

water districts who value their water less than the purchasing industry or business.

5. The free market allocation system is compatible with existing legislation. This system would not be a radical departure from the existing ordinances. Under the Monterey County Water Resources Agency Act (Stats. 1990, Chap. 1159), the Monterey County Water Resources Agency (MCWRA) has the authority to grant water rights to private parties or organizations. This authority is supported by the Mutual Prescription Doctrine. In 1972, California State Supreme Court ruled in favor of the Mutual Prescription Doctrine, which allows "a basin to be adjudicated[12] and a safe level of extraction be determined. A share of the rights are then allocated to the groundwater users in the basin on the basis of their extraction prior to adjudication." [Ref. 11:p. 228]

6. Ecological flexibility will result since the majority of the published theoretical privatization plans allocate water rights (the amount of groundwater a user is allowed to consume) on the basis of a percentage of the annual recharge rate of the aquifer the user's zone. Therefore this type of allocation system automatically reduces groundwater consumption rates during times of drought.

7. Under a free market allocation system, water consumption can be easily monitored and rights enforced due to recent advances in well monitoring technology and communications. This statement is verified by the Tehachappi - Cummings County Water district's demonstrated ability to define and enforce groundwater recharge rights. [Ref. 18:p. 107] A monitoring program has already been established through MCWRA Ordinance No. 3717 which require all wells that have a 3" inside diameter or larger discharge pipe to be monitored through the use of flowmeters.

8. A free market system requires less political involvement than the other two allocation methods. This is due to the fact that the government does not determine the amount of water a certain industry or individual will be allocated. This reduces the possibility of economic

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[12]Judicial decision will determine the legal and safe level to which groundwater can be extracted. All well owners will be required to adhere to the level of pumping that will result in this level of groundwater.

inefficiencies caused by special interest groups. Favoritism could influence the initial allocation of water rights, but it would not affect the final distribution.

2. Disadvantages of Privatization

The following are the basic disadvantages of this allocation method:

1. The government's lack of knowledge and experience in using this allocation method is the greatest disadvantage. A search of literature on this subject only indicated that one water district is currently using this allocation method (Tehachappi - Cummings). However, a number of air pollution control agencies have used this method to a limited extent. In these cases, the government has established markets to allow private parties to trade air pollution emissions credits. For example, the Environmental Protection Agency (EPA) established the Emissions Trading (ET) program. The most extensive such privatization program to date is the RECLAIM program managed by the South Coast Air Quality Management, in Los Angeles, CA. This program fully implements the idea of freely tradeable sulfur oxide (SOX) and nitrogen oxide (NOX) rights between private parties and organizations. This program took effect in 1994.

2. This allocation system may have a negative financial impact on the MCWRA. This system does not inherently generate revenue to cover the cost of developing and operating the program. This impact would be reduced if the revenue generated from penalty charges for violating established water rights offsets the cost of the verification program for water use reporting. This revenue stream could also be supplemented by implementing a surcharge or value added tax on the exchange of water shares or credits. The metering program cost can be borne by the individual well owners.

IV. PROPOSED THEORETICAL FREE MARKET (PRIVATIZATION) GROUNDWATER ALLOCATION PLAN FOR THE SALINAS VALLEY GROUNDWATER BASIN

The current water allocation problem in the Salinas Valley provides a rare challenge to local politicians: to devise an allocation method that will prevent overdrafting in the Salinas Valley Groundwater Basin and yet allow continued economic growth. Traditionally, water allocation in the United States has been controlled by regulatory systems. However, a Rand Corporation water efficiency study has stated that "the information difficulties in such an activity (the regulatory system of control) appear to us to be overwhelming, and we reject central planning as a feasible method of achieving efficient use of water" [Ref. 19:p. V]. The Rand Corporation defines water use as efficient when the marginal costs of supplying water, both private and public, (public costs are those costs not borne directly by the water users), just equal the marginal benefits to water users.

Recently there has been a great deal of success in the environmental field with air pollution emissions trading. This has demonstrated that innovative approaches can achieve greater cost savings and efficiency than the traditional regulatory control system (i.e., maximum emission standard approach). This greater efficiency occurs in a market system

because those who value the resource most highly may purchase it from those who value it the least, and both parties are made better off. This exchange will not occur under a regulatory control system. Thus, a free-trading market leads to the same efficiency as a regulatory control system with perfect knowledge. This perfect knowledge is only attainable in the world of theory.

A. A FREE MARKET ALLOCATION PROPOSAL

This section proposes a free market water allocation program for the SVGB. The proposed program has the potential to eliminate the overdrafting, while still allowing for economic growth. The primary mechanism to achieve such goals is to modify the way in which water rights within the Salinas Valley are held.

Currently, water rights in the Salinas Valley Groundwater Basin (SVGB) are not transferable, and restrictions have been established on the maximum amount of ground-water that may be pumped (Ref. MCWRA Ordinance No. 3744 & 3720). However, under this proposed free market allocation program the ultimate users (i.e., farmers) are allowed to choose between using their allocated water, or conserving it, saving the cost of pumping, and selling their excess water to other consumers. Users in the area who need additional water may either reduce their operations, increase the efficiency of their conservation programs or pay for additional water rights.

They should be willing to buy additional water as long as both the lost profit from reducing operational capacity and additional conservation costs are greater than the market price of water.

The ability to sell groundwater rights will increase the incentive for efficient groundwater use within the Salinas Valley. It provides a profit incentive for the well owner to conserve water and to sell the unused portion of their water rights for a profit.

This proposed allocation program must provide clear, definable and enforceable water consumption rights which are easily transferable between well owners. This program must also allocate initial water consumption rights in a fair and equitable manner in order to prevent a long and expensive adjudication processes.

The basic framework of the proposed allocation program has been broken down into the following elements:

1. Participants and program coverage.
2. The trading units, water credits and water shares.
3. The policy for allocating initial water shares.
4. The policy for allocating initial water credits.
5. The recharge water volume per water share and thresholds on pumping activity.
6. The guidelines and restrictions for the trading program.
7. The location of the trading zones and other restrictions on trading.

8. The monitoring and enforcement program.

9. The procedures for new commercial water users to obtain water credits or shares to secure groundwater resources and policy on closing of existing wells.

10. The proposed allocation program's organizational structure.

This allocation program is patterned after the Regional Clean Air Incentives Market (Reclaim) program of the South Coast Air Basin located in Los Angeles, CA. Each element in the proposed plan will be described and supporting arguments given for the various choices. However, to ensure a smooth transition from the current allocation program to the proposed allocation plan, the spectrum of choices is limited in order to take full advantage of the existing MCWRA ordinances on groundwater allocation.

B. PARTICIPANTS AND PROGRAM COVERAGE

The proposed allocation program will only affect well owners who pump from the Salinas Valley Groundwater Basin. The target participants of this allocation program are governmental, agricultural, commercial and industrial well owners in the Salinas Valley. These well owners consume more than 90% of the total groundwater pumped out of the Salinas Valley Groundwater Basin [Ref. 4]. The easiest way to identify these participants and separate them from residential well owners is by the size of the discharge pipe on their individual wells. Typically, the inside diameter of the

discharge pipes of private residential wells does not exceed three inches [Ref. 4]. The target participants cannot be identified by historical water consumption because the majority of the well owners have not kept accurate records of their water use. Thus, it would be impossible to calculate accurate historical figures for these water users. [Ref. 4]

The proposed allocation program will require all well owners with a discharge pipe having an inside diameter of at least three inches to participate in the program. To prevent well owners from subverting this policy, a supporting requirement will state any property owner having multiple wells on a single continuous piece of property must participate in the program if the combined inside diameter of their discharge pipes has a cross-sectional area greater than 28.274 inches. (This is equal to the cross-sectional area of a pipe with an inside diameter of three inches.) The cross-sectional requirement will prevent current and future owners with multiple wells on single properties from avoiding this program by retrofitting or drilling new wells with the discharge pipes having an inside diameter less than three inches. The MCWRA's allocation program uses the same threshold for identifying participants in their surcharge and agricultural upper pumping limit ordinances. Using the same threshold reduces the implementation cost and ensures a smoother transition for the new allocation program.

C. THE TRADING UNITS, WATER CREDITS AND WATER SHARES

The most critical element of the water allocation program is the trading unit. Before trading units can be defined, one must understand the two fundamental water assets: the water held in storage in the basin and the recharge water that flows into the basin. This proposed allocation program must establish procedures whereby these fundamental assets can be divided into definable units which then can easily be transferred or sold to public or private parties. This is a fundamental requirement in establishing a free market allocation system. The trading unit denoting ownership of water held in storage in the basin is a water credit; the trading unit denoting ownership of the recharge water is a water share.

The water held in storage in the basin is divided into two zones: live storage and dead storage (See Figure 4-1) [Ref. 14:p. 230]. In a natural state (without any pumping), aquifer storage capacity (water stock) is equal to the amount of water in live and dead storage. Live storage reserves are defined as the body of water that would flow out of the aquifer if it were not naturally replenished. Dead storage reserve is the body water that would remain in the aquifer after all live storage reserves were exhausted through natural outflow or drainage to the ocean. In terms of this allocation plan, the live storage reserve is a checking account and dead storage is a savings account with a severe penalty for early withdrawal.

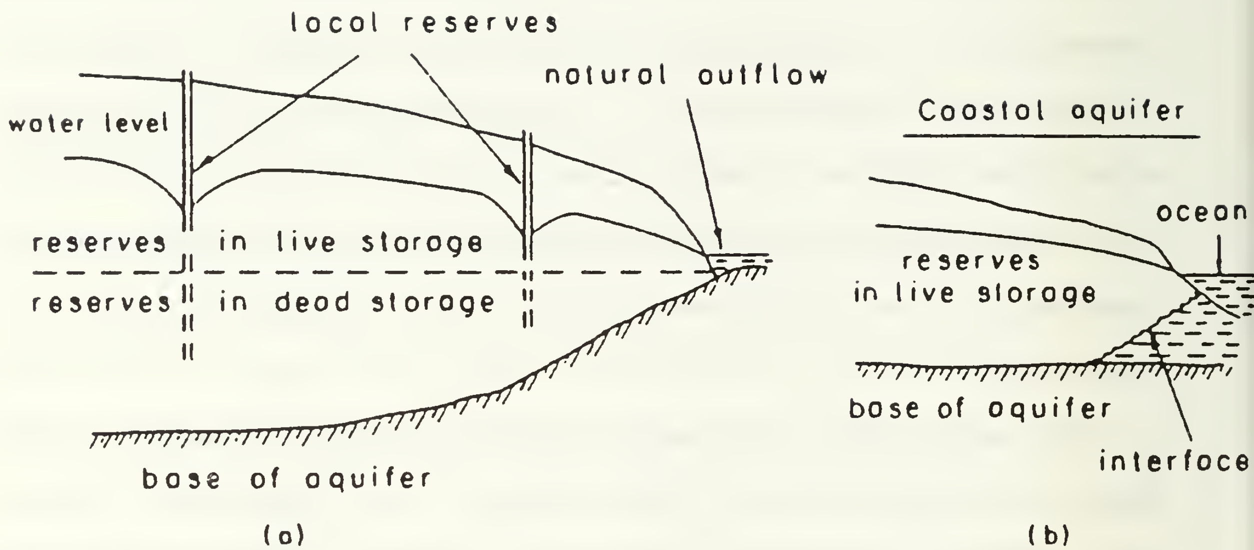

Figure 4-1. Live and Dead Storage in the SVGB

The proposed allocation program will give the MCWRA sole ownership of the dead storage reserve. The program allows the MCWRA to transfer or sell all or a portion of the basin's dead storage reserve to private parties at a later time.

1. Water Credits

In this proposed program, a water credit denotes ownership of the water held in the aquifer. Each water credit represents legal ownership of one acre-foot of water in the aquifer for an indefinite period of time.[13] Under the proposed program, these water credits can be freely traded or banked by the owner for indefinite period of time. The single limitation is that a water credit can only be redeemed for water within the zone in which it originated.

Water credits will initially be allocated to the MCWRA based on the best available hydrological data about the current amount of water stored in the Salinas Valley Groundwater Basin. Private parties can obtain these water credits by purchasing them from MCWRA or receive water credits from MCWRA for conserving water over a period of time.[14]

Water credits provide economic incentive for well owners to conserve groundwater and improve the proposed program's water allocation and conservation efficiency through

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[13] One water credit = 1 ac-ft = 325,850 gallons of water.

[14] Water conserved is defined as the amount of groundwater authorized for consumption minus the amount actually consumed at the end of the annual reporting period.

free-trade. They also provide a vehicle for well owners to slowly acquire ownership of the water in the groundwater basin. Most of the live storage reserve in the Salinas Valley Groundwater basin has been exhausted. The private parties and MCWRA will become co-owners of the basin's live storage reserve as it is replenished through net recharge flow into the groundwater basin and water conservation.

2. Water Shares

A water share is a trading unit used to describe water that can be safely extracted from the aquifer based on the net annual recharge. Each water share represents an indefinite legal right to a thousandth of a percent of the safe extraction volume based on the prior year's net recharge for that zone. Under this definition, 100,000 water shares per zone are available for distribution; there are 400,000 shares for the entire SVGB. With approximately 4,000 qualifying wells, an average 100 shares can be distributed to each well owner in the valley.

These water shares can be freely traded, but only within the zone where the water share originated. Any water share not fully exercised by the end of the reporting period would be retained by its owner as a water credit.

For example, suppose a well owner owns 100 water shares within a zone that has a 10,000 acre-feet (ac-ft) annual recharge rate. The well owner can pump 10 ac-ft of groundwater that year. If only 9 ac-ft of groundwater is

pumped that year, the well owner automatically receives one water credit at the end of the year.

D. THE POLICY FOR ALLOCATING INITIAL WATER SHARES

Under this program, MCWRA would have two alternatives for allocating the initial water shares: it could sell its shares, for either a fixed price or by auctioning them off to the highest bidders; or it could allocate shares to existing well owners based on prior groundwater consumption, acreage owned or a combination of both. One benefit of the free-trade allocation system is "that the ultimate allocation of these permits (shares) among the emitters (parties) will be cost-effective regardless of their initial allocation as long as the permit (shares) market is competitive, which was formally proven by Montgomery in 1972" [Ref. 17:p. 251].

The process of auctioning or selling water shares is relatively straight forward. The auction process could be patterned after the National Economic Research Associates, Inc.'s report on "Market-based Approaches To Reduce The Cost of Clean Air in California's South Coast Basin." This auction process requires interested parties to submit sealed bids to MCWRA. Each bid would include the number of water shares in each zone the bidder wishes to purchase and the bid price for each. Once all of the bids are submitted, the market-clearing price would be determined; i.e., the highest price at which

the number of shares demanded equals the quantity being offered. If a bidder's bid price is higher than or equal to the clearing price, the bidder would receive the number of shares at the price bid. Shares purchased at this auction could be traded, held, or banked by conversion to water credits at the end of each annual reporting period.

The process of selling water shares at a fixed price is similar to the process of selling water shares at an auction. In this scenario, MCWRA would have to estimate the market-clearing price prior to the sale. The time and day of the sale would be announced publicly. The shares would be sold on a "first come, first served" basis. This is similar to current concert or athletic event tickets sales.

The magnitude of the revenues collected from an auction or fixed price sale of water shares could be substantial. For example, the current mean recharge rate for the Salinas Valley Groundwater Basin (1970-92 years) is 498,000 acre-feet per year [Ref. 2:pp. 5-14]. Based on historical research by the Rand Corporation on California water documents and statistics, the market price of water in a free market allocation program is predicted to be roughly equal to the extraction cost plus $15 to $30 per ac-ft of water. The exact amount is impossible to predict with present data [Ref. 19:p. 61]. Since current well owners do not pay for the privilege of pumping groundwater from the basin, the predicted water share price would be between $15 to $30 based on Rand Corporation

estimates. Therefore, MCWRA could conceivably generate revenue between $7,470,000 and $14,940,000 from selling these water shares.

The revenue collected from this sale or auction could presumably be used to fund water projects that would increase the recharge efficiency of the basin, and/or develop or import new water resources into the valley. An alternative use of the funds would be to reduce other taxes imposed by local area governments.

This sale or auction could cause at least one negative side effect. It would theoretically separate the value of the land from the value of the water underneath it. Thus, land values could decrease, lowering the community's property tax revenue.

An alternative approach to fixed price sales and auctions is to distribute initial water shares freely to current well owners based on acreage, historical consumption or a combination of both. If water shares are allocated by acreage, it would benefit the agricultural community more than private industry. (Private industry consumes significantly more water per acre of land than the farming community.) If water shares are allocated by historical consumption, members of the farming community would receive different allocations according to their prior choices of crops and/or method of water application. Furthermore, water users who have previously invested in conservation methods would be

penalized. Thus, either allocation scheme would be considered unfair by certain parties.

The way to minimize these problems is to combine both allocation schemes. Water shares could be allocated based on historical consumption for industry, governmental and institutional well owners. For the farming community, water shares could be based on acreage; specifically, farmable acreage times the water consumed per acre by the highest water consumption crop grown in that zone. This allocation scheme reduces the inequity created by differences in water consumption versus acreage owned as well as inequalities created in the farming community by individual crop choice, irrigation method, and past conservation practices.

This combination approach to allocating initial water shares is likely to receive more support from the community than the two methods mentioned earlier. The majority of well owners typically feel they still retain riparian rights to groundwater underneath their land. Well owners would probably feel indignant about purchasing something they believe that they already own.

Allocating water shares by a combined approach would be relatively straight forward. MCWRA would first determine the historical safe groundwater extraction volume for each of the four hydrological trading zones, using for example a mean five year average for the period 1982-1987. (This period was

selected because it was the last normal five year recharge period before the 1988-1992 drought.)

The second step requires all industrial, governmental and institutional well owners to document their water consumption for 1982 through 1987. This would be used to calculate their mean annual water consumption rate. If this data is not available, or is currently inaccurate, they may use the 1988 - 1993 period to derive their mean annual water consumption rate. If there is no water consumption data, MCWRA would then determine mean annual water consumption based on the best available engineering estimates. Well owners in the farming community would be required to submit figures giving their total acreage and their farmable acreage.

The third step is to subtract the zone's total industrial, governmental and institutional annual water consumption rate (IAWC) from the zone's mean historical annual safe extraction volume (ASEV). The difference (IAWC-ASEV) is divided by the farming acreage (((IAWC-ASEV)/ Acres)=Z). This determines the annual groundwater per acre (Z) for the farming community.

A second set of calculations are then worked back through again to determine if the individual farmer is receiving a fair and equitable amount of water. This is accomplished by multiplying the acres owned by an individual farmer (Acres) by the groundwater per acre for farmers (Z). This is compared to the amount calculated by multiplying historical farmable

acreage[15] (FA) by the consumption rate of the crop with the highest annual water consumption per acre (AWCC in Acre-feet) in that zone (which in most zones will be lettuce or celery). Annual water consumption rate figures per acre per crop will be based on standards established by Monterey County Agricultural Extension Service. The farmer's annual consumption rate is the greater of these two calculations. This process is repeated for each agricultural farmer with wells.

The revised farming community's annual water consumption rate is then added to the industrial, governmental, institutional community total. This is the total annual mean consumption rate for that zone. It will be greater than the mean annual safe extraction volume for the zone[16]. To correct for this, the annual safe extraction volume is divided by the total annual consumption. This yields a correction factor. To calculate the maximum authorized annual consumption for an individual well owner, the well owner's annual consumption rate (as calculated above) is multiplied by the correction factor.

Once all well owners' authorized annual consumption rates have been calculated, the number of shares per well owner is

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[15]The historical farmable acreage will be determined by examining historical crop revenue and production records.

[16]This is due to the allocation process for the farming community. This process allows the farming community to have a higher authorized annual consumption rate than its historical annual consumption rate would indicate.

determined. Recall that a water share is a thousandth of a percent of the safe extraction volume. The number of shares to be issued to each owner are calculated by dividing each well owner's authorized annual consumption rate for that zone by the annual historical recharge rate for that zone and then multiplying by 100,000 (the number of shares that will be allocated in the zone). The result is the number of water shares that the individual well owner receives as an initial allocation. This allocation scheme tries to minimize inequalities, but some may remain. Of course, the initial allocation will not affect the final distribution of shares. It only determines the initial owners of water shares.

This allocation process does not create wealth for individual well owners (current owners already receive this wealth in the form of groundwater). It simply defines the value of this wealth more clearly. Providing the well owners "with clear title to the groundwater will not add to their wealth but will merely allow them to transform their wealth from water into money, if they so wish, by reducing their water use" [Ref. 19:p. 38]. New wealth will only be created as former inefficiencies in the use of water are eliminated. This new wealth will be shared widely among the existing water users in the individual zones.

E. THE POLICY FOR ALLOCATING INITIAL WATER CREDITS

MCWRA has three choices for allocating rights to the initial stock of groundwater held in the aquifer. The agency can retain ownership over the existing groundwater, allocate it to well owners, or a combination of both. These groundwater rights are held as water credits. Each credit represents one acre-foot of groundwater. The initial number of water credits will be based on an independent engineering estimate of the total volume of groundwater held in the Salinas Valley Groundwater Basin.

Currently, the valley's well owners have extracted most of the groundwater in the aquifer's live storage reserves and have begun extracting groundwater from the dead storage reserves. Evidence supporting this includes seawater intrusion and the increasing concentrations of dissolved minerals (hardness). Seawater intrusion occurs when the basin's groundwater reserve drops below the natural water level of the dead storage reserves. Hardness of the groundwater generally increases as water is extracted from the dead storage reserve. Hardness is directly related to the length of time the water interacts with soluble minerals. In other words, the length of time the water is held in the basin. The water held in the dead storage reserve is the oldest water in the basin. Thus, it usually has a higher concentration of dissolved mineral content than the water held in the live storage reserve.

Allocating the water stock in dead storage to the MCWRA does not affect the system's allocation efficiencies. This assumes that the dead storage reserves would only be consumed in times of drought or to stabilize the market price of water shares or credits, in a manner similar to the way that the Federal Reserve Board controls the U.S. currency system. It is critical that MCWRA does not abuse this ability because of the serious side effects caused by extracting too much groundwater from this region, i.e., seawater intrusion, permanent damage to basin's holding capacity, devaluation of water shares and credits.

If and when a serious drought occurs, it is also assumed that the MCWRA will use the dead storage reserve water credits to increase the water authorized for extraction. This would reduce the economic hardship placed on well owners by a drought.

Considering the externalities associated with consuming the aquifer's dead storage reserve, the groundwater rights to the dead storage reserve should be retained by the MCWRA. In addition, the MCWRA should be able to sell or transfer these groundwater rights at any time. This allows MCWRA additional flexibility to influence the open market price of groundwater. They can buy and sell water credits, just as the Federal Reserve board influences interest rates by buying and selling government bonds.

F. THE RECHARGE WATER VOLUME PER WATER SHARE AND THRESHOLDS ON PUMPING ACTIVITY

Under this system, the volume of groundwater represented by one share is based on the prior year's recharge volume in the Salinas Valley Groundwater basin. MCWRA already calculates this volume each year, as required by the Monterey County Water Resources Agency Act. (Stats. 1990, Chap. 1159) Recharge volume determines the amount of groundwater that can be extracted without harming present and future basin use. The proposed allocation plan simply requires the MCWRA to determine the prior year's annual safe extraction volume individually for the four hydrological trading zones in the Salinas Valley.

Once the prior year safe extraction volume has been determined, it is simple to establish the groundwater volume per water share. As described in Section C of this chapter, one water share represents one one-thousandth of a percent of the safe extraction volume based prior year's recharge for the particular zone in question. To calculate the volume per share for a particular zone, simply divide the established recharge volume for that zone by 100,000.

The proposed allocation plan uses the prior year's recharge volume. This is primarily based on historical rainfall data and stream measurements. The current year's recharge volume would be based on projected estimates of rainfall and stream flows. Using prior year volumes will

reduce the amount of subjectivity and judgement required to calculate the recharge volume. MCWRA can determine the safe extraction volume for the prior year with a high degree of accuracy using engineering estimates from the agency's network of monitoring stations for rainfall, reservoirs, rivers and streams.

To avoid negative externalities when an individual well owner exceeds the well's natural extraction capacity, limits need to be set on the flow rate for groundwater pumping. The limit should be based on the hydrological and geological conditions at the well and the proximity to neighboring wells. The negative externalities that may occur in these circumstances are:

1. Development of a localized cone of depression that would cause soil subsidence to take place somewhere within the localized area. This devalues that property and permanently reduces the aquifer holding capacity.

2. Localized lowering of the water table increases the pumping costs for adjoining wells.

The task of establishing extraction limits for individual wells will mostly likely be assigned to the MCWRA. The agency will need to define extraction flow limits based on the number of gallons per hour, per day, per hydrological season and per year.

One issue that needs to be resolved is whether or not to restore the groundwater stock to its natural volume. This thesis won't discuss this issue but provides the necessary means. One possibility would be to allocate 95% of the annual

safe extraction volume to well owners, retaining the rest to build up the reserve groundwater stock. The basin has been overdrafted by 7.4% from 1970 to 1992, based on the current groundwater model developed by Montgomery Watson. Eliminating this overdraft and allocating 5% of the annual safe extraction volume to replenish the groundwater stock is probably the maximum that is economically feasible.

G. THE GUIDELINES AND RESTRICTIONS FOR THE TRADING PROGRAM

This allocation program incorporates trading to encourage participants to reduce groundwater consumption in a way that minimizes society's total conservation costs. Owners and operators of groundwater wells will be able to purchase water shares and credits to increase their groundwater allocation. Well owners who reduce their groundwater consumption by any means can sell their unneeded shares. Private parties who do not own or operate groundwater wells will also be allowed to purchase and sell water shares and/or credits, which will promote market efficiency.

For this allocation system to maximize efficiency and operate smoothly, the trading rules need to be simple, accessible and enforceable, while still maintaining the system's integrity. The National Economic Research Associates, Inc. identified three market requirements through a feasibility study of a free market approach to reducing air

pollution emissions in the Los Angles area [Ref. 20:p. 3-17]. These market requirements include:

> The market is to be efficient. This means that the cost of accessing the market, completing a transaction, and responding to new market or price information is minimized.
>
> The market is to be capable of disseminating accurate and timely price and volume information for past and current transactions, and expectations for the future.
>
> The market is to be liquid. A buyer and seller must have the ability to complete a trade quickly at a price similar to previous transactions.

Using these three requirements, a variety of market structures can be used to establish a trading system. There are two major types of markets: the *direct search market*, which allows buyers and sellers to seek out their own trading partners; and the *broker market* that uses an intermediary to identify and assist interested buyers and sellers in completing their transaction. For direct a search market to be efficient, participants must have direct access to market and price information, as well as a list of interested parties willing to exchange their resources. An example of such a market is the used-car market.

Since water rights markets are relatively new, a broker system appears to be the most appropriate market structure. The broker system should help eliminate participants' confusion and stimulate market participation. A broker market system would be similar to the stock market. An individual would go to the MCWRA (the broker) to purchase or sell water

shares or credits. The MCWRA broker would charge a small fee for each market transaction processed. This revenue would offset the administrative costs of acting as the broker.

To establish this market, all well owners who are required to participate in the program would register in a trading zone according to their well location. Any person or organization who owns or may own water shares or credits would also be registered. The proposed program would delineate those actions that would change the participant list. These actions would include: adding or subtracting water shares or credits to the official record of ownership due to financial transactions, registering new participants, removing participants, and changing well owners or participants named in the record.

Each existing well owner would be allocated their water shares based on the initial water allocation plan. Share ownership would be recorded at MCWRA. A copy of the official allocation, as well as the groundwater extraction limitations, would be sent to each individual well owner. Each participant would receive a copy of their official water consumption and transaction report each quarter. The report would be similar to a bank account statement. It would be divided into three sections: credits, debits, and net position. The credit section would be divided into five subsections: the number of water shares owned at the beginning of the period; the number of water shares purchased; the number of water credits purchased; the number of water credits earned; and the total

of all credits, expressed in acre-feet of groundwater. The debit section would have three subsections: the groundwater extracted (prior and current), the number of water shares sold, and the number of water credits sold. The last section details each participant's net position. This is the amount of groundwater available to be extracted or sold. (See Figure 4-2)

Once well owners have received their official water allocation, they may sell their water shares at any time. Water credits may be sold after the program has existed for one reporting period and the participants have received their official report. The trading process is fairly straight-forward. An individual who wishes to sell or buy water credits or shares places an order with the MCWRA Trading Desk. Sellers indicate the number of shares or credits they wish to sell and the price per share or per credit. The seller can either sell at the current market price, or set a price higher than market and hope there is excess demand at the current price.

The same process describes buyers. Buyers can place an order for water shares or credits at the current market price or at a lower price hoping that there is excess supply at this price. Each order would stand for a set period (e.g., thirty days) or until the order is executed, which ever comes first. Upon expiration, individuals can either renew or remove their orders. If MCWRA does not receive directions to the contrary,

CREDITS	#	DATE -	PRICE -	ACRE/FT
Beginning of the period, water shares Owned	#	-------	-------	#####=C1
Water Shares Purchased during this period, Purchased From ________,	#	///	$$$$	#####
" " " "	"	"	"	" "
" " " "	"	"	"	" "
		Subtotal =		#####=C2
Water Credits Purchased during this period, Purchased From ________,	#	///	$$$$	#####
" " " "		"	"	" "
" " " "		"	"	"
		Subtotal =		#####=C3
Number of water credits earned prior to this period,				#
Number of water credits earned this period,				#
		Subtotal =		##=C4
Total Credits to date (C1+C2+C3+C4)		Total =		#####=C5

DEBITS	#	DATE -	PRICE -	ACRE/FT
Total groundwater extracted prior to this period,				##
Total groundwater extracted this period,				##
Subtotal =				###=D1
Water Shares Sold during this period, Sold to ______________,	#	///	$$$$	#####
" " " "		"	"	"
" " " "		"	"	"
		Subtotal =		###=D2
Water Credits Sold during this period, Sold to ______________,	#	///	$$$	####
" " " "		"	"	"
" " " "		"	"	"
		Subtotal =		###=D3
Total Debits to date (D1+D2+D3)		Total =		####=D4

NET POSITION		
NET BALANCE FOR THIS PERIOD (C5-D4) (If negative, penalty form with a fine would be included. Also a penalty form would be included if the individual violated any groundwater extraction limitation)		######

Figure 4-2. Example of the Quarterly Report

the order would automatically be removed. After completing a trade, both the buyer and the seller would receive official notification. The funds would automatically be transferred to the seller's individual bank account. The buyer has ten working days to settle his account. Any debt outstanding past this allotted time would result in the automatic reversal of the sale.

The MCWRA would also be able to purchase and sell water credits or shares under this program. This allows the agency to influence the market price. They may also reduce groundwater extraction in the groundwater basin by purchasing water credits and shares and retiring them from the market indefinitely.

This type of trading program is working extremely well for the South Coast Air Quality Management District in Los Angeles. However, this trading program is managed by commercial security brokers and not by the district.

H. THE TRADING ZONES AND OTHER RESTRICTIONS ON TRADING

Trading zones are established to match the basin's ability to reach a new localized equilibrium after shifting groundwater extraction from one location to another. The amount of time it takes the aquifer to reach a new localized equilibrium is a critical element in defining trading zones. It determines the physical distance over which water transfers can take place without negatively affecting the aquifer.

Hydrological and geological structures in the basin have created zones that are conducive to this allocation plan. Trading between these zones should not be permitted because the soil lacks sufficient hydraulic conductivity to balance the groundwater across zones in a reasonable amount of time (greater than year). Based on discussions with MCWRA, it appears that the four prior established hydrological regions would seem to make reasonable trading zones. (See Figure 2-2 in Chapter II) However, this area of the allocation plan requires further research.

Water shares and credits can only be posted to an individual's groundwater extraction account if that account is registered in the zone from which the share or credit originates. This requirement, however, does not preclude individuals from purchasing and/or selling water credits or shares from other zones for investment purposes.

An additional restriction may be placed on the trading program to prevent a massive water sellout by the agricultural community. A massive sellout could cause structural changes in local economies. This appears to be very unlikely due to the economics of farming. Conversations with people in the agricultural community suggests that most farmers would probably modify their crop pattern and/or intensity of irrigation to maximize profits from both selling their water rights and farming. However, to reduce probability of these structural changes water sellers could be restricted to

transferring some maximum percentage of their water shares in the first year. This percentage could rise in succeeding years until ultimately reaching unlimited transfers. This would give time to absorb the effects of the transfers and alleviate any undesired externalities.

I. THE MONITORING AND ENFORCEMENT PROGRAM

Monitoring and enforcing this kind of allocation system requires the technical ability to detect pumping violations and the legal ability to punish detected violations. Monitoring extraction rates is a key aspect of this and any other allocation system. Without it, well owners would most likely cheat the system for economic gain. The allocation system efficiencies and incentives to conserve groundwater would be lost. Thus, it is critical to detect violators and sufficiently penalized them to minimize the incentive to cheat. The fine would have to be determined via the political process.

Remote sensors (RTU) tied to the flowmeter[17] on individual wells would make it possible for a single agency to monitor historical and real-time pumping activity of hundreds of wells throughout the valley. The monitoring system could use a small high-speed business computer with large memory capacity and a high speed modem. This computer could be data linked to all the wells in the Salinas Valley via the telephone/LAN line or a cellular network. The computer could obtain data from each remote sensor on a daily basis. The software would calculate and record the amount of groundwater extracted from each well, and identify violators who exceed their pumping limitations.

The computer could also be used to record water shares and credits and track trades. Using this data, it could compile and print the official water extraction quarterly and annual reports. With this monitoring system, the operator could also monitor any well's real-time pumping activity without notifying the well owner. This would help deter cheating. This monitoring system would establish a definable and

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[17]Each individual well would have a frequency generator, analog/digital converter, microprocessor with data storage capability, and a built-in high-speed modem capable of reading and recording the flow rates from the installed flow meter on the individual well. This RTU could be powered from either the phone power source, or by solar power for remote wells that require data transmission through a cellular network. Remote sensors would have the capacity to store 48 hours of data. The system operator could shut the system down for up to 48 hours for maintenance or repairs without losing any data.

enforceable system for protecting individual water shares and credits. It could be used in conjunction with any allocation plan.

J. PROCEDURES FOR NEW COMMERCIAL WATER USERS TO OBTAIN WATER CREDITS OR SHARES TO SECURE GROUNDWATER RESOURCES AND POLICY ON CLOSING EXISTING WELLS

This proposed allocation system would not allocate additional shares to new commercial wells. The overall groundwater extraction limit is restricted based on the annual safe extraction volume and the amount of water credits turned in for consumption. This ensures that the Salinas Valley Groundwater Basin is never overdrafted except during times of severe drought. As in numerous existing pollution trading programs (i.e., the Federal Government Acid Rain program and Reclaim NOX-SOX program), a new commercial well owner would have to obtain water shares and/or credits from existing owners before extracting groundwater from the Salinas Valley Groundwater Basin. The requirement to purchase water shares and/or credits for a new well would be the same whether the well is owned by a firm or organization participating in the initial allocation, or by a firm which has not previously participated in the trading program. Thus, this system does not impose unfair barriers to entry by new participants.

This proposed allocation system would also allow the MCWRA to transfer or sell its water credits to new firms relocating in the Salinas Valley. It gives local government the flexi-

bility to give financial incentives to encourage new firms to relocate in the valley by offsetting their relocation and initial operating costs.

K. DESCRIPTION OF THE PROPOSED ALLOCATION PROGRAM'S ORGANIZATIONAL STRUCTURE

The proposed organizational structure assumes that there will be fewer than 4,000 participants in the program. The number of participants affects the size of the accounting and trading program departments. The layout for the organizational structure is patterned after MCWRA's existing organizational structure.

The proposed organization would presumably be a division of the MCWRA organization. This division would be managed by a "Water Conservation Manager" in accordance with the Monterey County position classification guidelines. This Water Conservation Manager would be responsible for operating this water allocation division. The manager would also act as facilitator and local expert on the water allocation system at all governmental meetings concerning water conservation or allocation. An administrative secretary/receptionist would be assigned to support the manager and the division's administrative requirements. (See Figure 4-3)

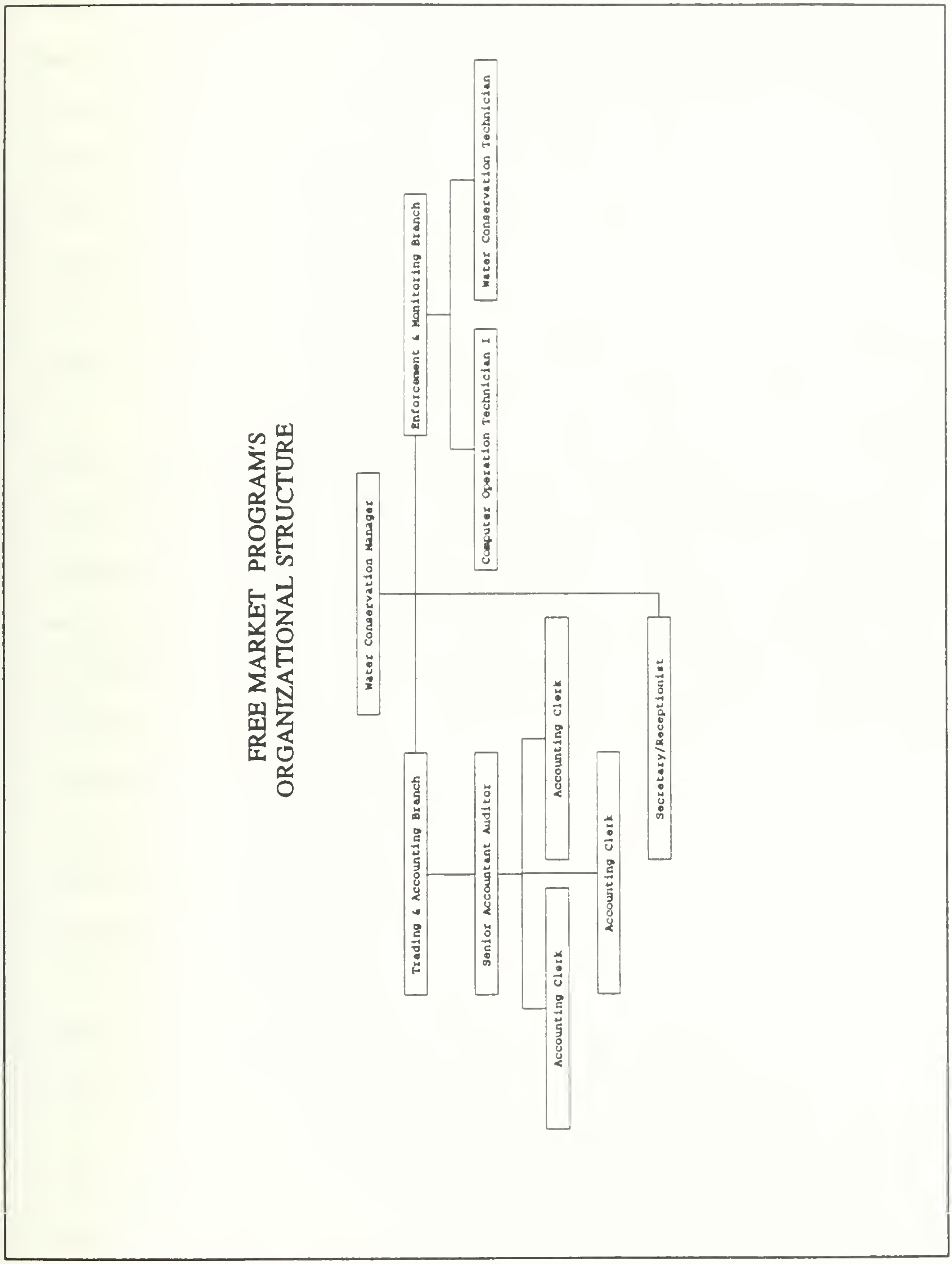

Figure 4-3. Free Market Program's Organizational Structure

This organization would be divided into two branches, the Enforcement & Monitoring branch and the Trading & Accounting branch. The Enforcement & Monitoring branch would operate and maintain the computerized monitoring system, including the remote sensors. It would inspect all commercial wells (defined by this allocation program) to assure compliance with the allocation program. This branch would include a "Computer Operation Technician 1" and "Water Conservation Technician." These two individuals would report directly to the Division manager.

The Trading and Accounting branch would execute and record all traded water shares and credits and produce the quarterly and annual allocation reports. This branch would be supervised by a "Senior Accountant Auditor," who would operate the trading program. This individual would be assisted by "Accounting Clerks." The clerks would act like account brokers, assisting program participants in trading their water shares and credits. They would also record these transactions. Based on conversations with Paine Webber Inc. and USAA Brokerage Services, three Accounting Clerks would be required to handle 4,000 customer accounts. This assumes that program's participants will require less time than a client requires with a full service stock broker, but more time than with a discount broker.

This proposed administrative structure will be used in the following chapter to determine whether the MCWRA regulatory

control program or the proposed free-trading allocation program has lower implementation costs. This information will be used in determining which program has higher overall economic efficiency.

V. ANALYSIS OF THE MCWRA WATER GROUNDWATER ALLOCATION PROGRAM AND A PROPOSED FREE MARKET GROUNDWATER ALLOCATION PROGRAM

This chapter examines whether the proposed free market allocation plan provides greater economic efficiency than the MCWRA allocation scheme for a selected group of property owners in the SVGB. This analysis examines the cost of establishing each program and the estimated economic impact each will have on three sectors of the Salinas Valley: the industrial sector (focusing on agricultural production companies), the urban water sector and the agricultural farming community. Each sector is analyzed by taking a selected company or farm and estimating the cost of complying with each program, and the effects over time of these allocation programs on the three sectors.

The industrial sector has a high water consumption rate and is one of the major employers in the Salinas valley. The J. M. Smucker Company was randomly selected from the major agricultural production companies operating in the Salinas Valley.

The representatives from urban water districts were chosen from three subgroups: large urban water districts, small urban water districts and privately operated water districts. The following organizations were selected: the City of

Salinas (large urban water district); the Marina Coast Water District (small urban water district); and the California Water Service Company (privately operated water district).

Farms were selected based upon the owner's ability to provide accurate historical data on crop acreage, crop yield, production cost and net profit after packing and growing costs. Since this data is extremely proprietary, individual farmers are not identified. Data from all farms in the group were averaged. Sixteen farms participated in the analysis. They are located in or near: Greenfield, Soledad, Gonzales, Salinas, Castroville, and Chualar. At the time of this research, no farm in the group had accurate records of water consumption per acre, by crop type. Nor did any of the farms have records of the efficiency of their irrigation equipment. Therefore, this analysis used published average water consumption per acre of irrigated crop land, as developed by the Montgomery Watson Groundwater model [Ref. 2:pp. 2-3 & 4-15].

The analysis for determining the compliance cost for the free market allocation plan assumes that subsample representatives can purchase or sell as much water as they desire at the prevailing market price. This assumption will be reexamined at the end of the chapter.

The theoretical forms of the equations used in this chapter can be found in Appendix A. This appendix also describes the assumptions made in these equations. The

fifteen equations described in Appendix A are referenced in this chapter by (EQ. #) immediately preceding the applicable statement. For example, (EQ. 4) $1,562 indicates that equation 4 in Appendix A was the basis for the calculation that led to the value $1,562.

The specific numerical calculations that were made using these equations are contained in Appendix B. These calculations are numbered from 1 to 162 and are referenced by subscripts. For example, $\$1,562_6$ indicates that the numerical value $1,562 was obtained using calculation number 6 in Appendix B.

A. INITIAL PROGRAM DEVELOPMENT AND OPERATING COSTS

Several assumptions are required to analyze the cost of establishing each allocation plan. First, no organization currently exists to implement and monitor either allocation scheme. Organizations for both plans will be treated as new, independent divisions of the MCWRA organization. This requires the agency to hire new personnel, purchase support equipment and furniture, and lease additional office space to house the new division.

MCWRA currently appears to have insufficient staff to properly manage any type of water allocation program. Therefore, an idealized administrative structure will be proposed for both allocation plans, understanding that economic reality will probably reduce the size of the selected

organization by making use of existing administrative resources within MCWRA. The administrative organization for the proposed privatization allocation plan was described in Chapter IV. The administrative organization for the MCWRA allocation program will be described in the following section of this chapter.

The final fundamental assumption concerns the number of participants in the allocation program. Under the Monterey County Water Resource Agency Ordinance No. 3660, all well owners with discharge pipes of 3" inside diameter or greater are required to register their wells with MCWRA by July 1, 1993. Currently 2,100 such wells have been registered [Ref. 4]. Well industry analysis estimates that there are approximately 3,500 to 4,000 qualifying wells operating within the Salinas Valley [Ref. 21]. Both allocation plans have the same participation requirements, so a population of 4,000 participants is used for this analysis. Note that of all the wells in the SVGB, those having an inside diameter of 3" or greater are estimated to account for more than 90% of the groundwater extracted from the aquifer each year [Ref. 21].

1. Implementation and Operating Cost Analysis

a. MCWRA Water Allocation Program

The administrative structure described here is based on interviews with the administrative staff of the MCWRA about job classification, command and control relationships, anticipated workload and reporting hierarchy (See Figure 5-1).

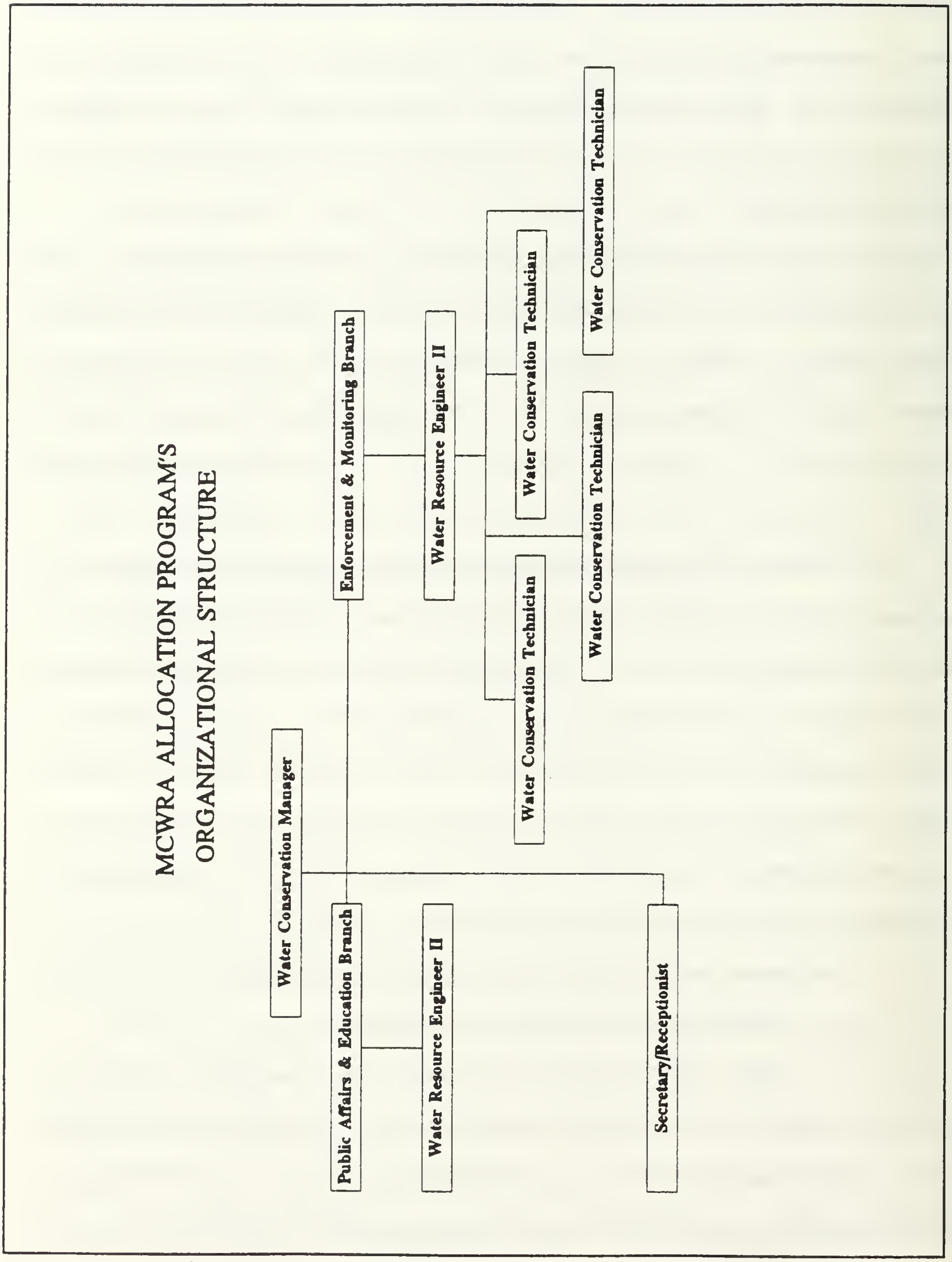

Figure 5-1. MCWRA Allocation Program's Organizational Structure

This administrative structure is not MCWRA's proposed organization since it was developed by the author. It is a structure, proposed for this analysis, that meets MCWRA's functional and operational requirement. It was verified by MCWRA's senior staff in a series of meetings. All salary levels for this organization comply with the Monterey County county-wide list of position classifications and pay requirements.

(1) Personnel classification & costs. This new division would be headed by a Water Conservation Manager. Responsibilities of the Division Manager would include managing day-to-day operations, providing strategic planning for the division and representing the MCWRA in all water allocation matters. The monthly salary for this position can range from $3,542 per month to $4,388 per month, based on the individual's seniority and experience. The median monthly salary for this position is $3,942 per month.

This division would also need an administrative assistant. This person would be responsible for clerical and support duties. While these duties may be handled using current resources in the MCWRA, this analysis assumes that the division won't rely on existing MCWRA resources. The salary range for this position is between $2,151 and $2,665 per month, while the median salary is $2,394 per month.

The division would have two departments: the enforcement and monitoring department and the public

affairs and education department. The enforcement and monitoring department would be supervised by a Water Resource Engineer II. This person would supervise and plan workloads of the Water Conservation Technicians. The salary range for a Water Resource Engineer is from $3,065 to $3,797 per month, based on experience and seniority. The median salary for this position would be $3,412.

The Water Conservation Technician would be responsible for examining wells, reading water-meters and measuring the water level. MCWRA estimates that a Water Conservation Technician could survey 20 wells per day, and that the agency would survey all wells once every quarter. Four Water Conservation Technicians would be required to monitor 4,000 wells assuming 260 work days in a fiscal year and two weeks vacation per year [Ref. 22]. The monthly salary range for a Water Conservation Technician is from $2,536 to $3,142 based on experience and seniority. The median salary for this position would be $2,822.

The Public Affairs and Education Office would be staffed by a Water Resource Engineer II. This person would implement and maintain public affairs and educational programs for the urban and agricultural industries and represent the MCWRA at all public functions involving water conservation and allocation issues. The range and median salary for this position are the same as for the Enforcement & Monitoring department head.

In total, the MCWRA's water allocation program would consist of eight people with salaries ranging from $25,812 to $52,656 per year. Based on the median salary for each job position, the total salary for this division would be $24,448 per month or $293,376 per year.

EMPLOYEE COST: Classification	**No.**	**Monthly Salary**	**Yearly Salary Cost**
Water Conservation Manager	1	3,942	47,304
Admin Sect/Phone Rep.	1	2,394	28,728
Water Resource Engineer II	2	3,412	81,888
Water Conservation Technician	4	2,822	135,456
Program Total Salary Cost:			**$293,376**

The net present cost over 12 years at a 4 percent discount rate is (EQ. 1): $2,753,363_1$

(2) Furniture and personal computer costs. The cost of purchasing new office furniture and computer equipment for the department is based on historical costs obtained from the County of Monterey's Purchasing Office, Support Services Division [Ref. 23]. The following are considered standard allotments for this type of organization:

Managers are allocated $5,000 for office furniture.

Department personnel are allocated $3,500 for modular office furniture.

Each employee is allotted $2,500 for one personal computer with software and printer.

Each employee is allotted $550 for a four drawer filing cabinet.

The department is allotted $300 for a conference table and six chairs at $140 per chair.

The department is allotted $1000 for miscellaneous supplies and paper stock.

Summary of these costs:	No.	Cost	Subtotal
Office Furniture			
Manager	1	5,000	5,000
Department Personnel	7	3,500	24,500
Personal Computers	8	2,500	20,000
Filing Cabinets	8	500	4,400
Conference Table	1	300	300
Conference Chairs	6	140	840
Misc. Supply	1	1,000	1,000
Total			**$56,040**
Net Present Cost = $56,040			

(3) Transportation costs. The division must provide a vehicle for each Water Conservation Technician so that the technician can inspect wells in the Salinas Valley. The cost of operating and maintaining the necessary four vehicles is $3,600 per month based on the following assumptions [Ref. 24]:

A two passenger 1/4 ton pick-up truck would meet the transportation requirement for a technician.

The operating and maintenance (O&M) cost for a two passenger pick-up truck equals the MCWRA's historical cost for this type of truck.

MCWRA continues to self-insure these vehicles.

The MCWRA's historical fuel and maintenance cost for a 1/4 ton pick-up truck is $900 per year. The current cost of this vehicle is $9,800 using a fleet discount

rate [Ref. 24]. The life expectancy is 8 years and projected salvage value afterwards is $1,200 [Ref. 24]. The discount rate is assumed to be 4% per year, and the agency uses straight-line depreciation for their trucks.

Summary of Vehicle Costs	**No.**	**Cost**	**Subtotal**
Initial Truck Purchase	4	9,800	39,200
Annual Operating Costs	4	900	3,600
Salvage Value	4	1,200	4,800
2nd Truck Purchase at the end of 8th year Based on a 4% inflation rate (EQ. 2)	4	13,412[2]	53,648

The net present cost over 12 years at a 4 percent discount rate is:

Net Present Cost (12 years at 4% discount rate)	**NPC**
Truck Fleet Purchase	39,200
Operating Cost (EQ.1)	33,786[3]
2nd Truck Fleet Purchase (EQ. 3)	28,986[4]
Salvage Value of 1st Fleet (EQ. 2)	(3,507)[5]
Salvage Value of 2nd Fleet based on the 12 year service life (EQ. 2)	($13,741)[10]
Total NPC:	**$84,724**

(4) Office space costs. Currently the MCWRA doesn't have adequate office space for its employees. It would be unreasonable to assume that this additional department could share the agency's existing space. The MCWRA is currently residing in temporary office trailers; it is assumed that additional trailers would be leased.

Monterey County has not established administrative requirements for office space based on job position and duties. Therefore, this analysis uses federal standards for government employees to determine the required office-space. The specific standards used here are based on the facility planning criteria of the Naval Facilities Engineering Command for Navy & Marine Corps (NAVFAC P-80, Oct 82).

Classification	**No.**	**SF Allotment**	**Subtotal**
Administration Manager	1	120 SF	120
Secretary	1	85 SF	85
Personnel	6	85 SF	510
Conference Room	1	150 SF	150
Total ft^2 for the Department:			**865**

A 24 ft by 40 ft trailer would satisfy the department's space requirements. The cost of leasing this trailer, preparing the site, transporting the trailer to the site, hooking up the utilities and modifying the interior for administrative use are presented below. This data was obtained from the General Electric, Inc. - Capital, Modular Space Division which has leased trailers to Monterey County in the past.

Description of individual costs	Cost
Monthly lease	$ 475
Delivery cost of the trailer	$ 1,300
Setting up the trailer including utility hook-up	$ 1,200
Installation of seismic tie-downs	$ 1,000
Dismantling fee for terminating contract	$ 1,200
Shipping cost for returning the trailer	$ 1,300
Total set-up cost is	$ 3,500
Total cost of terminating the lease is	$ 2,500
Expected life of the trailer is 12 years	
Net present costs (calculations based on a 4% discount factor).	**NPC**
Set up cost	3,500
Termination cost (EQ. 3)	1,562[6]
Lease payments (EQ. 1)	53,495[7]
Total Present Cost:	**$58,557**

(5) Summary of the organizational costs. Based on the proceeding calculations, the following table summarizes the organization's initial capital and operating costs.

Item	Capital Cost	Annual Oper. Cost
Salaries	0	293,376
Furniture/P.C.	56,040	0
Transportation	39,200	3,600
Office Space	5,002	5,700
Total:	**$100,242**	**$302,676**

The net present cost for implementing and operating this organization is presented in the following table. The calculations cover a 12 year period and use a 4 percent discount rate.

Item	**NPC**
Wages/Salaries	2,753,363
Furniture/P.C.	56,040
Transportation	84,724
Office Space	58,557
Total:	**$2,952,684**

b. Proposed Free Market Allocation Program

(1) Personnel classification and costs. The analysis in Chapter IV described the administrative structure for the proposed privatization allocation scheme in terms of job classification, command and control relationships, anticipated workload and reporting hierarchy. While this administrative structure is not necessarily the ideal organization, it does meet the allocation plan's functional and operational requirements. All salary levels for this organization concur with the Monterey County county-wide list of position classification salary guidelines, and all salary requirements are reported at their median value.

EMPLOYEE COST: Classification	No.	Median Monthly Salary	Total Yearly Salary
Water Conservation Manager	1	3,942	47,304
Admin Sect/Phone Rep.	1	2,394	28,728
Water Conservation Technician	1	2,822	33,864
Senior Computer Oper Tech	1	2,466	29,592
Senior Accountant Auditor	1	3,429	41,148
Accounting Clerk	3	1,671	60,156
Program Total Salary Cost:			**$240,792**

Net present cost over 12 years at a 4 percent discount rate (EQ. 1) is $2,259,857[8].

(2) Furniture and personal computer costs. New office furniture and computer equipment costs for this department are based on the same assumptions as the previous alternative. These costs are summarized below.

Summary of Costs:	No.	Cost	Total
Office Furniture	1	5,000	5,000
Manager	7	3,500	24,500
Department Personnel	8	2,500	20,000
Personal Computers	8	550	4,400
Filing Cabinets	1	300	300
Conference Table	6	140	840
Conference Chairs	1	1,000	1,000
Misc. Supply			
		Total:	**$56,040**
Net Present Cost = $56,040			

(3) Computerized monitoring system costs. West Plant Systems, Inc. of Monterey, CA, estimated the cost for purchasing and installing a computerized monitoring system.

In this system, each well would have a frequency generator tied into the well's flowmeter 4-20 milliampere tap. This frequency generator is then wired, either remotely or directly, into a remote terminal unit (RTU). The cost for purchasing and installing the frequency generator is estimated to be $1,100. The RTU consists of an analog/digital converter and a programmable microprocessor that can accept up to eight inputs and one output. The unit can transmit and receive digital data via LAN network or standard phone line (Modem). It has the capacity to hold 48 hours of data before downloading the information to a central unit. The RTU has the capacity to monitor and transmit data for eight wells. This would lower the per unit cost of installation for well owners with multiple wells. This RTU is estimated to cost $2,700.

Assuming, on average, that three wells will be connected to each RTU, the cost of installing this monitoring system for 4,000 wells would be $7,999,100. The cost of a computer to monitor the system is estimated to be $1,900. Thus, the total cost of the system would be $8,000,000. This cost includes all programming and labor. The value of the system is assumed to depreciate linearly over its service life of 20 years and have no salvage value at the end.

The operational cost of the equipment is estimated to be $12.00 per month per well. This cost includes the line transmission fees and a system maintenance contract.

The total operational cost per year for 4,000 wells is estimated to be $576,000.

The net present cost calculations for this capital improvement using a 4% discount factor over 12 years is:

Item	NPC
Purchase and installation of equipment	$ 8,000,000
Operational Cost and Maintenance (EQ. 1)	$ 5,405,818[9]
Salvage value at the end of 12th year (EQ. 2)	($ 1,998,720)[11]
Total NPC:	**$11,407,098**

(4) Office space costs. The office space required for this department is the same as in the previous alternative.

Classification	No.	SF Allotment	Total
Administration Manager	1	120 SF	120
Secretary	1	85 SF	85
Personnel	6	85 SF	510
Conference Room	1	150 SF	150
Department Total:			**865**

Based on the requirement of 865 square feet, a 24 ft by 40 ft trailer would accommodate the needs of the department. This is the same requirement as the previous alternative. Thus, the net present cost is $58,557, the same as before.

(5) Summary of the organizational costs. Based on the preceding calculations, the initial capital and operating cost of the organization required under this alternative are as follows:

Item	Capital Cost	Annual Oper. Cost
Wages/salaries		240,792
Furniture/P.C.	56,040	
Monitoring System	8,000,000	576,000
Office Space	5,062	5,700
Total	**$8,061,102**	**$822,492**

The net present cost of the initial capital investment and operating costs for this organization are presented below. The calculations are based on a 12 year time horizon and a 4 percent discount rate.

Item	NPC
Wages/Salaries	2,259,857
Furniture/P.C.	56,040
Monitoring System	$11,407,098
Office Space	58,557
Total:	**$13,781,552**

2. The MCWRA Program Versus the Free Market Program

Based on the preceding calculations, the MCWRA allocation program has lower implementation and operating costs than the free market program. This is largely due to the initial purchase and operating costs of the well monitoring system. If the monitoring program costs were

excluded from both net present cost (NPC) calculations, the NPC of the free market program would be $2,090,180$_{12}$ while the NPC of the MCWRA program would be $1,560,278$_{13}$. The difference between the two programs would now only be $529,902 rather than $10,828,868.

If the free market program operated on the honor system, with the pumping volume verified once a quarter, the NPC would be $3,472,372$_{14}$. In this case, the free market allocation program is less expensive than the MCWRA program if it reduces water conservation costs by at least (EQ. 4) $55,374$_{15}$ per year in the SVGB.

B. INDUSTRIAL SECTOR COST ANALYSIS

The industrial sector cost analysis is based on one of the largest agricultural processing and packaging plants in the Salinas Valley, the J. M. Smucker Company's California Farm Products Division. It is also one of the leading employers in the Salinas Valley. This company was randomly selected from this subgroup, and the most current data available was collected from it.

The J. M. Smucker Company is an Ohio-based corporation founded in 1897 and incorporated in 1921. This corporation currently employs 1,950 full-time employees at thirteen production or administrative facilities throughout the world. The company's only industrial operation is the manufacturing and marketing of food products such as: preserves, jams,

jellies, fruit-only spreads, fruit and vegetable juice beverages and other fruit products.

The company's products are sold primarily through brokers to chain, wholesale, cooperative, and independent grocery accounts, food service distributors and the hotel industry. This business segment is highly competitive in product quality, price, advertising and promotion.

This analysis focuses on Smucker's California Farm Products Division located near Watsonville, California. This division produces fruit spreads and toppings from apples, oranges, peaches, strawberries and apricots. This fruit is generally purchased from independent growers and suppliers, although the company does grow strawberries for its own use. This division employs roughly 400 full-time employees during its peak production time, late spring and summer. They have 150 full-time employees during the rest of the year.

Due to the perishability and seasonality of fresh fruits, the Division has more than 100,000 square feet of cold storage space as well as 15,000 square feet of processing area. The division can produce more than 50 million pounds of finished product each year. In processing fruit spreads and toppings, large quantities of water are required to wash the fruit and convert it into spreads. During a normal eight hour shift, a single production line will use over 50,000 gallons of fresh water. This division's actual annual water use from 1987 to 1993 and its forecasted water use from 1994 to 1996 are

presented below. Forecasted water use is based on a five year moving average and the division's projected 5% annual increase in water use for the next three years.

Water Usage (ac-ft)						
1987	1988	1989	1992	1991	1992	1993
100.11	82.98	144.72	154.36	124.04	178.34	135.9
Five year mean (89-93) = 147.47						
Projected Water Use						
1994	1995	1996				
154.84	162.58	170.71				

Water consumption per pound of finished product has decreased from one gallon per pound in 1990 to .81 gallon per pound, or 1,620 gallons per ton in 1993 [Ref. 32]. This 19% reduction in water use resulted from a $70,000 water conservation program. The water conservation program consisted of changes in procedures for washing the exterior of the fruit as well as more extensive use of recycled water. This program will save an estimated 28.063 ac-ft of water per year in the future, based on the historical 1989 thru 1993 five-year mean water use. The average cost of reducing water consumption by 19%, or 28.063 ac-ft, is (EQ. 5) $99.78[16] per ac-ft. This calculation assumes that this water savings would continue in the future with no additional investment or special maintenance required. This is consistent with the fact that

Smucker's maintenance and operational costs did not increase due to these modifications.

The "Survey of Water Use in the California Food Processing Industry in 1993," published by the California League of Food Processors, contains typical water use in processing several products [Ref. 25:p. 5]:

Product	**Gallons per Ton**
Apple Sauce	275
Apricots	2,992
Artichokes	766
Asparagus	808
Brussels Sprout	808
Frozen Fruits	1,780
Garlic	2,800
Onions	1,700
Pears	4,174
Raisins	2,000
Seafood	2,700
Vegetable Oils	6,094
Yams	6,094
Zucchini	7,975

The Smucker's division seems to be using water more efficiently than other California processing plants. This statement is supported by the fact that Smucker uses 1,620 gallons of water to process one ton of apricots while the industry average is 2,992 gallons per ton [Ref. 32].

Before the Division will invest in water conservation, one of the following conditions must hold: the conservation investment is required by law, or the economic return from the investment must be high enough to satisfy the corporation's investment criterion. The Smucker Company's investment criteria are a 36% return on investment and a two year payback period for the present value of the capital investment. The two year payback requirement is the most difficult of the two criteria to meet.

Currently, Smucker has only two viable projects for conserving water: expansion of the current water conservation program and a membrane filtration project. Both projects have been placed on indefinite hold because their economic returns on investment fail to meet the two year payback requirement.

If the company was forced to increase its water conservation efforts immediately, it could achieve a maximum 5 to 7 percent additional savings with a $100,000 investment (excluding any major capital investment in water recycling equipment) in the current program. Thus, the average cost of this 5 percent, 7.37 ac-ft[18] additional annual reduction would be roughly (EQ. 5) $542.74[17] per ac-ft.

The company could further reduce water consumption by investing in a Membrane Filtration System. This system would allow Smucker to use recycled water to process their product.

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[18] 7.37 ac-ft is calculated by multiplying 5% by five year historical mean (89-93). (7.37 = .05 X 147.47 ac-ft)

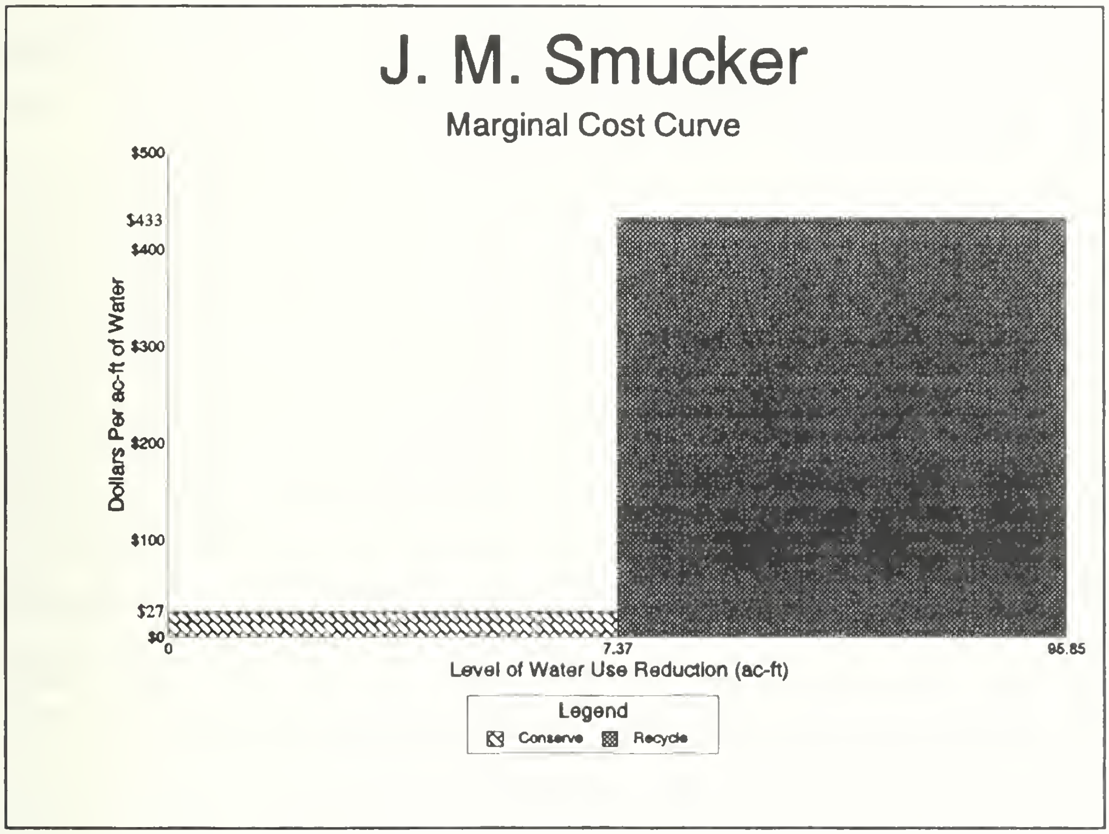
This filtration system would reduce water usage between 60% and 75%. The initial investment is $250,000 to $300,000 and the annual operating cost is $50,000. The projected life expectancy is ten years. Using a $275,000 initial investment, a $50,000 annual operating cost and a 60% water-use reduction, the annual average cost of reducing one ac-ft of water per year (EQ. 1 & 4) is $948.27[18]. This project also requires the U.S. Department of Agriculture (USDA) to approve using this recycled water in Smucker's packaging process. (Such use of recycled water is not currently allowed by the USDA.)

Currently, the Smucker's California Farm Products Division receives water from two sources: the Pajaro Water District and private wells. This division pays an average of $36,000 per year for public water and $40,000 per year to operate its own water wells. Thus, the division's average annual cost of receiving water is $76,000 per year which equates to $515.36[19] per ac-ft of water. Based on this calculation, the average annual cost of reducing water use by one ac-ft for the two proposals is:

1. Additional investment in current program: $27.38[20] per ac-ft.
2. Membrane Filtration system: $432.91[20] per ac-ft.

1. Marginal Cost Curve For Reducing Water Use

The following marginal cost curve was generated by using the preceding data and analysis for J. M. Smucker Company.



J. M. Smucker
Marginal Cost Curve
$500
$433
$400
$300
$200
$100
$27
$0
Dollars Per ac-ft of Water
0
7.37
95.85
Level of Water Use Reduction (ac-ft)
Legend
Conserve
Recycle

2. Economic Cost of MCWRA Allocation Plan

The following table presents Smucker's cost of compliance with MCWRA Ordinance No. 03774 in 1994, 1995 and 1996. MCWRA Ordinance No. 03774 requires urban water districts to reduce water use by 15% per capita (or per customer account) when compared to 1987 water use. This analysis assumes that urban water districts would require industries in each district to reduce water use by 15% based on 1987 water use. The MCWRA allocation program does not specifically address what water conservation actions are required by urban industrial water users. The program allows each urban water district to determine its own policy on industrial water use, as long as the total water use for the district is less than the authorized level per MCWRA Ordinance No. 3774. Therefore, this analysis took a conservative approach: assume that the urban water districts will pass the required 15% water use reduction on to the industrial water users.

Table 5-1 (EQ. 6) shows the estimated cost per year for the company to comply with the MCWRA allocation program, assuming that Smucker would have to reduce water use by 15% compared to 1987 water use. The ordinance limit was calculated by multiplying the 1987 water use by 85%. Economic cost per year was calculated by using the preceding marginal cost curve and the required water use reduction for 1994, 1995 and 1996.

TABLE 5-1. J. M. SMUCKER COMPLIANCE COSTS WITH MCWRA PROGRAM

Year	Projected Water Demand (ac-ft)	Ordinance Limit	Required Reduction	Economic Cost/Yr
94	154.84	85.09	69.75	$27,210
95	162.58	85.09	77.49	$30,561
96	170.71	85.09	85.62	$34,081

This analysis assumes that Smucker chooses to invest in conservation rather than reducing its output to achieve the required reduction in water use. If water conservation costs reduced profit to unacceptable levels, Smucker may choose to conserve water by reducing output. This option might be particularly relevant to the decision Smucker faces concerning the membrane filtration system, since this system is so expensive. Unfortunately, analyzing this option would required detailed proprietary information regarding Smucker's operating costs and profit margins. Since this proprietary information is unavailable, Smucker is assumed to maintain output levels, even if the cost of conserving water essentially doubles, as with a membrane filtration system. This is a reasonable assumption if water costs are a small portion of the total production costs.

3. Economic Cost of the Free Market Allocation Plan

Table 5-2[19] presents the economic cost of compliance under the thesis allocation plan for 1994, 1995 and 1996. These results are based on the preceding marginal cost curve, the projected shortfall each year and the following assumptions:

1. The company would choose to use the mean of the last five years for their historical use figure. Average water use = AEA = ((FY88 + FY89 + FY90 + FY91 + FY93) / 5).

2. Average net reduction for the zone is equal to the total recharge for the zone divided by the total discharge (ANR = Total Recharge / Total Discharge).

3. The company's water share allotment in acre-feet would be equal to the average net reduction of the zone multiplied by the five year average water use (allotted Annual Extraction Amount (AAEA) = AEA X ANR).

4. Based on the Montgomery Watson Groundwater Model, the Total Discharge for the valley = 535,000 ac-ft per year and the Total Recharge for the valley = 498,000 ac-ft per year. Therefore, ANR = 498,000 / 535,000 = .93.

5. Five year average water use at Smucker = 147.47 AC-FT Allocation Limit = 137.15 ac-ft = .93 X 147.47.

6. Subsample representatives will be able to purchase or sell as much water as they desire at the prevailing market price.

The top portion of Table 5-2 presents the projected water demand, allocation limit and the shortfall each year.[20] The

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[19]This table was created using equation 7 in Appendix A, and the calculations are shown in Appendix B, line 21-35.

[20]The shortfall is the amount of water that is required to be conserved and/or purchased in order to fulfill the projected water demand for that year and be in compliance with the proposed free market program.

lower portion of the table presents the projected annual economic cost of compliance under the free market program.

TABLE 5-2. J. M. SMUCKER COMPLIANCE COSTS WITH THE PROPOSED FREE MARKET PROGRAM

YR	Projected Water Demanded	Allocation Limit	Shortfall
94	154.84	137.15	17.69
95	162.58	137.15	25.43
96	170.71	137.15	33.56
Compliance Costs			
YR	**No Water Trades (Regulatory System)**	**Mkt. Price of Water is $15/ac-ft**	**Mkt. Price of Water is $30/ac-ft**
94	$ 4,668	$265	$509
95	$ 8,019	$381	$741
96	$11,539	$503	$985
YR	**Mkt. Price of Water is $75/ac-ft**	**Mkt. Price of Water is $100/ac-ft**	**Mkt. Price of Water is $200/ac-ft**
94	$ 973	$1,231	$2,263
95	$1,554	$2,005	$3,811
96	$2,163	$2,818	$5,437

4. Comparison of the Economic Costs for the Two Allocation Plans

The preceding analysis dramatically demonstrates that the cost of compliance is much less for the proposed allocation plan than for the MCWRA allocation plan. The range of cost savings that can be achieved in 1994, 1995, and 1996 is

shown in Table 5-3.[21] This cost comparison reflects water use reduction as required in each of the programs. Thus, the water use reduction increases from the free market plan to the MCWRA plan. For Smucker, the MCWRA program requires a higher reduction in water use.

TABLE 5-3. COST SAVINGS PER YEAR AS A FUNCTION OF THE MARKET PRICE OF WATER

YR	No Water Trades (Regulatory System)	Mkt. Price of Water is $15/ac-ft	Mkt. Price of Water is $30/ac-ft
94	$22,542	$26,945	$26,701
95	$22,542	$30,180	$29,621
96	$22,539	$33,574	$33,291
YR	**Mkt. Price of Water is $75/ ac-ft**	**Mkt. Price of Water is $100/ac-ft**	**Mkt. Price of Water is $200/ac-ft**
94	$26,237	$25,979	$24,947
95	$29,007	$28,556	$26,750
96	$31,914	$31,259	$28,640

To show the inherent advantages or disadvantages of a particular program requires comparing compliance costs for a given level of water use reduction. The graph in Figure 5-2 illustrates that the proposed allocation program has an

[21]The definition of "Cost Savings" for this analysis is the subsample representative's cost of compliance under the MCWRA's program minus its cost of compliance under the thesis' proposed program.

inherent advantage over the MCWRA allocation program. This graph is developed from Smucker's marginal cost curve for water conservation and the water conservation required under both plans for 1994. (MCWRA's required level of reduction is 69.75 ac-ft per year and the proposed program's reduction is 17.69 ac-ft per year). The diamonds on the graph correspond to the cost savings calculations reported in Table 5-3. The no water trade (i.e., regulatory system) case reported in Table 5-3 corresponds to a $443 market price of water. At this price Smucker would choose not to buy or sell water.

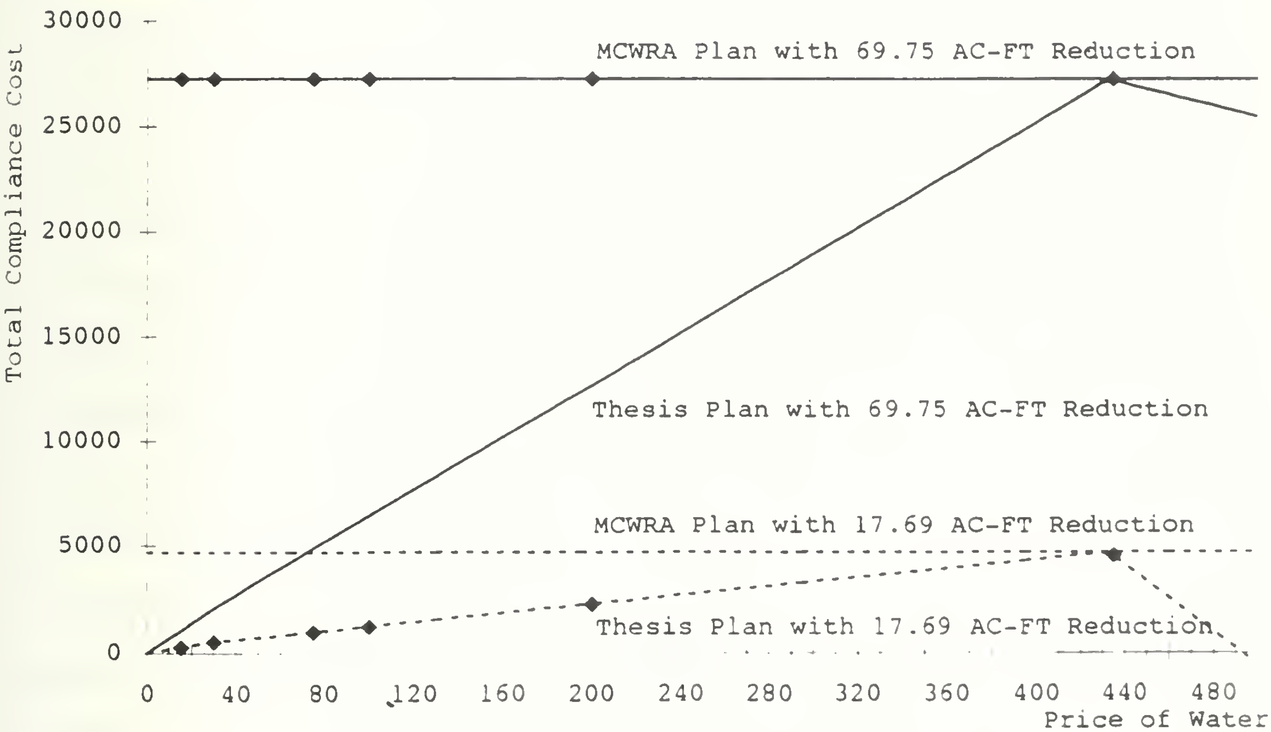


Figure 5-2. Industrial Sector Cost Analysis

Note that the 17.69 ac-ft per year reduction is based on a 7% reduction from a five year average selected by the company. On the other hand the 69.75 ac-ft per year reduction is based on the MCWRA program for a 15% reduction (for urban users) from 1987 water use.

When the level of reduction is 17.69 ac-ft annually, the graph shows the compliance cost for MCWRA program will be $4,667.55. The free market allocation program's compliance cost depends on the market price of water. The market-based program's cost does not approach the MCWRA programs cost until the open market price of water reaches $433 per ac-ft. For market water prices below $27 per ac-ft, the representative would purchase water rather than implement water conservation measures. For market prices between $27 and $433 per ac-ft, the representative would save 7.37 ac-ft of water through conservation and purchase the remaining shortfall from the market. Purchases would still be cheaper than installing the membrane filtration system. Both programs have similar costs when water prices equal $433 per ac-ft, the marginal cost of compliance for a 17.69 ac-ft annual reduction. At this price, the representative would neither buy or sell water; it would meet its required reduction through internal conservation measures, as with the MCWRA program. Finally, the market-based program's costs decrease for water prices exceeding $433 per ac-ft. The company could install a membrane filtration system, reduce its water use more than required, and sell its excess water on the open market. This at least partially offsets its conservation costs. If water prices are high enough, Smucker could conceivably earn a net profit on water sales.

When the required reduction in water use is 17.69 ac-ft per year, the same cost comparison is repeated. This case illustrates that the absolute cost advantage of the proposed free market program increases with the level of water use reduction.

This analysis illustrates two points. First, the free market allocation program's compliance costs will always be lower or equal to those of a regulatory control system (MCWRA's allocation program). Second, as the level of reduction increases, so does the potential for savings from choosing the free market program in lieu of the regulatory program.

C. URBAN SECTOR COST ANALYSIS

The urban sector cost analysis is based on three urban water districts: the City of Salinas, the California Water Service Company, and the Marina Coast Water District. These water districts were selected based on location, service population and private versus public ownership. The City of Salinas represents a large urban community (115,000 residents) which is experiencing rapid population growth. The California Water Service Company's Salinas District (Cal Water) represents a privately held water utility serving a medium-size urban center (20,000 customers). It also has extensive historical data on water consumption and conservation. The Marina Coast Water District represents a small urban water

district (15,000 residents) mainly serving a residential community and a small, light industrial sector. It also has an active water conservation program. All three water districts are experiencing the negative externalities associated with overdrafting.

It should be noted that Cal Water provides water service to a significant portion of the City of Salinas. For the purpose of this analysis this overlap of customers is assumed to not exist. Due to this assumption, the total cost of compliance for the urban sample will be slightly overstated for both the MCWRA allocation program and the free market program. However, this will not affect the general results of the comparative analysis since both programs will be affected to the same extent.

1. City of Salinas

The City of Salinas is an agricultural, service, administrative and commercial hub for northern Monterey County. It is located roughly nine miles from the coast, 13 miles northeast of Monterey and two miles west of the Gabilan mountain range. Salinas has become the center for all of the Monterey County government offices. The City's population has grown 37 percent over the last ten years.

The central portion of the City contains retail operations, including strip and shopping malls, and government offices for both the City and Monterey County. Surrounding this central area is prime agricultural land, with the highest

agricultural land values and best soil conditions in the region. With the recent population growth, some low productivity farmland has been converted into residential housing. The city's industrial base is mainly composed of retail and service industries, as well as agricultural shipping and processing industries. Table 5-4 shows the 1986 employment by sector for the City [Ref. 27:p. 35]:

TABLE 5-4. SALINAS 1986 EMPLOYMENT BY SECTOR

Sector	**Percent of Total**
Agricultural	2.6
Mining	0.3
Construction	4.9
Manufacturing	11.4
Transportation/Public Utilities	5.7
Wholesale Trade	31.1
Finance, Insurance and Real Estate	6.5
Services	30.2
Other	2.0

Table 5-5 provides historical groundwater extraction volumes for the years 1987 to 1993 and projected values for 1994 to 1996. The City of Salinas only maintains groundwater extraction records for 1987.[22] Thus, this table was

[22]The City of Salinas is only starting to maintain a record of groundwater extraction volumes in order to comply with MCWRA allocation program in late 1993. The city had no

developed by multiplying the 1987 water use per capita by the annual population data obtained from the California Department of Finance, Demographic Research Unit report dated 04/28/93. The City used this procedure to report their projected groundwater demand to MCWRA as required under MCWRA Ordinance No. 3744.

TABLE 5-5. CITY OF SALINAS ESTIMATED GROUNDWATER EXTRACTION DATA

Historical Groundwater Extraction							
	1987	1988	1989	1990	1991	1992	1993
Wat.	28,411	30,247	30,714	31,355	32,375	33,132	33,744
Pop.	97,499	103,800	105,400	107,600	111,100	113,700	115,800
W/P =	.2914	.2914	.2914	.2914	.2914	.2914	.2914

Wat. = Groundwater in AC-FT extracted from the aquifer
Pop. = Population of their area of service
W/P = Groundwater extracted per capita

Projected Groundwater Extraction (without restrictions)							
	1994	1995	1996				
Wat.	35,025	35,742	36,472				
Pop.	120,197	122,655	125,163				
W/P =	.2914	.2914	.2914				

reason to maintain records since the water service to its residents is provided by private water service companies or by the individuals themselves.

2. California Water Service Company

The California Water Service Company (Cal Water) was incorporated on December 21, 1926 and currently operates in 38 communities statewide through 21 water systems. The company has over 500 wells statewide. It produces over 47 billion gallons annually, accounting for 47% of the company's annual production. The remaining 53% comes from surface sources purchased from wholesale suppliers and company owned watershed on the San Francisco Peninsula. Cal Water reportedly has one of the most modern water distribution and control systems operating today. They have also received national recognition for their innovative, informative water conservation programs.

In the Salinas division, Cal Water operates three wells located in the 180 foot aquifer, 32 wells in the 400 foot aquifer and no wells in the deep aquifer. These wells have the capacity to pump more than 10 million gallons per day. Cal Water has extracted a relatively constant amount of groundwater over the last seven years. However, the water extracted per service connection has declined by 9 percent between 1987 and 1993. This historical data is presented in the Table 5-6.

TABLE 5-6. CAL WATER GROUNDWATER EXTRACTION DATA

Historical Groundwater Extraction							
	1987	1988	1989	1990	1991	1992	1993
Wat.	13,588	12,539	14,154	13,797	11,984	12,842	13,353
Pop.	18,554	18,788	19,075	19,499	19,745	19,798	19,872
W/P =	.7323	.6674	.7420	.7076	.6070	.6487	.6720
Wat. = Groundwater in AC-FT extracted from the aquifer Pop. = Population of their area of service W/P = Groundwater extracted per capita							

The current forecast of groundwater volumes was supplied by Cal Water and also given to MCWRA as required under MCWRA Ordinance No. 3744. This information is also presented in Table 5-7. Cal Water determined the projected water extraction volumes by assuming that the water extracted will be the same per capita as in 1987 (Wat. = population x W/P (In 1987)).

TABLE 5-7. CAL WATER PROJECTED GROUNDWATER EXTRACTION DATA

Projected Groundwater Extraction (without restrictions)							
	1994	1995	1996				
Wat.	14,784	15,019	15,260				
Pop.	20,188	20,509	20,838				
W/P =	.7323	.7323	.7323				
Wat. = Groundwater in AC-FT extracted from the aquifer Ser. = Number of service connections W/S = Groundwater extracted per service connection							

3. Marina County Water District

The Marina County Water District (MCWD) is the primary water supplier for the 17,990 people in Marina, California. Its service area contains residential and light industrial users, including the City of Marina, RMC Lonestar, California Artichoke, the Dole Food Company, and part of the Armstrong Ranch. The MCWD is located on the coast in the Northwest corner of the Salinas Valley. The agency also collects and disposes of wastewater for the community. MCWD's wastewater reclamation program is projected to sell five ac-ft of reclaimed wastewater per month starting in mid-1994. The agency predicts this program will initially reduce groundwater pumping by 60 ac-ft per year.

Since 1960, the agency has acquired or drilled 14 wells. Eight have been abandoned: three because of casing failure and five due to chloride contamination from seawater intrusion or nitrate contamination from agricultural fields. Two wells are restricted to non-potable uses.

MCWD's three newest wells are drilled 1400 ft.into the deep aquifer to avoid chloride and nitrate contamination. The combined extraction capacity of these three newest wells and one well in the 400 ft. aquifer is 5,320 gallons per minute. MCWD's groundwater extraction has been relatively constant over the last seven years. However, the water use per capita has declined by 21 percent between 1987 and 1993. This historical data is presented in Table 5-8.

TABLE 5-8. MARINA COUNTY WATER DISTRICT GROUNDWATER EXTRACTION DATA:

Historical Groundwater Extraction							
	1987	1988	1989	1990	1991	1992	1993
Wat.	2,213	2,308	2,164	2,263	2,056	2,230	2,153
Pop.	14,596	14,848	14,952	17,060	17,412	17,939	17,990
W/P =	.1516	.1554	.1447	.1326	.1181	.1243	.1197

Wat. = Groundwater in AC-FT extracted from the aquifer
Pop. = Population of their area of service
W/P = Groundwater extracted per capita

MCWD's current water use forecast was provided by MCWD and was also submitted to MCWRA as required by MCWRA Ordinance No. 3744. This information is presented in Table 5-9. MCWD determined the projected water extraction volumes by assuming that the water extracted will be the same per capita as it was in 1987 (Wat. = population x W/P (In 1987)). This assumption may overestimate the actual demand because the per capita consumption has fallen by 21 percent since 1987. While MCWD has sufficient production capacity to meet its projected needs, seawater intrusion may degrade water quality in the deep aquifer, rendering these wells unfit for domestic use.

TABLE 5-9. MARINA COUNTY WATER DISTRICT PROJECTED GROUNDWATER EXTRACTION DATA

Projected Groundwater Extraction (without restrictions)			
	94	95	96
Wat.	2,729	2,729	2,729
Pop.	18,000	18,000	18,000
W/P =	.1516	.1516	.1516

4. Marginal Cost of Reducing Water Use

Water conservation programs are the most cost effective way to reduce water use. Water conservation programs usually involve Ultra Low Flow (ULF) Toilets, low flow showerheads, and public information and education programs to teach water conservation techniques and raise public consciousness. The marginal cost analysis for the urban sector will assume that the preceding water conservation programs would be implemented. In order to calculate the marginal costs of these programs the following assumptions were made:

1. The average single family household has the following characteristic:

   Persons per household = 3.0
   Toilets per household = 2.2
   Average household characteristics for multi-family units are:

   Persons per household = 2.5
   Toilets per household = 1.2

   These characteristics were based on conversations with AMBAG personnel and Richard Youngblood, Conservation and Special Projects Administrator at MCWD.

2. Ten percent of the average urban community has pre-existing Ultra Flow toilets and Low Flow showerheads.

a. ULF Toilet Program

The marginal cost per ac-ft of water saved by retrofitting existing homes with a Ultra Low Flow toilets depends on the average water savings per toilet and the cost of purchasing and installing new toilets. The California Urban Water Conservation Council estimated the effect of

retrofitting existing residencies with low flow toilets in their June 30, 1992 report entitled "Assumptions and Methodology for Determining Estimates of Reliable Water Savings from the Installation of ULF Toilets." Using this report and assuming an average of 3.0 people and 2.2 toilets per household, the average single family household would save 7,267 gallons or .0223 ac-ft per year +/- 5% by installing ultra low flow toilets. Assuming an average of 2.5 people and 1.2 toilets per multi-family residency, this would save 14,417.5 gallons or .0442 ac-ft per year +/- 5%.

Finally, the California Water Service Company has data concerning the ratio of single family and multi-family to total number of residencies. Assuming this data is representative of the districts considered here, this ratio is used to estimate a weighted average water savings per ULF toilet. Cal Water's statistics on the ratio of single family to total number of residential units are:

Year	Multi/Total
1987	.2561
1992	.2817
1993	.2807
Average:	**.2728**

Therefore, the average water savings per ULF toilet for this sample group is = .27(.0442) + .73(.0223) = .02821 ac-ft per year.

To determine the cost of purchasing and installing an ULF toilet, a telephone survey of local plumbers and plumbing supply stores indicated the following:

1. The local plumber's wage rate is approximately $50 per hour.

2. It takes approximately one hour to remove an existing toilet and install a new ULF toilet.

3. The Cost of a ULF toilet ranges from $79 to $299 with the average being $189.

4. The miscellaneous material cost is $10 per toilet.

Based on this information, the cost of purchasing and installing a ULF toilet ranges from $139 to $359, with the average being $249. The cost of saving for one ac-ft of water per year through installing an ULF toilet ranges from $363 to $936, where each toilet is expected to last 20 years (EQ. 8). For the economic analysis, the average of $649 per ac-ft per year will be used for the cost of reducing one ac-ft of water use by retrofitting with ULF toilets (EQ.8).

b. Low Flow Showerhead

The marginal cost of saving an acre foot of water by replacing existing showerheads with low flow showerheads depends on the average water savings per showerhead and the cost of purchasing and installing the new showerhead. The projected water savings of a Low Flow Showerhead is between 8,400 to 17,500 gallons per year, per person, according to "How to Get Water Smart" by Buzz Buzzelli and others [Ref.

33:p. 34]. This analysis will use the average value of 12,950 gallons which is equivalent to .03974 ac-ft per year.

The retail cost of purchasing a low flow Showerhead ranges from $5.99 to $15.95, with the mid-range price being $11.00. This data was obtained from a telephone survey of local plumbers and plumbing supply stores. For this analysis, the installation cost is zero. The majority of local plumbers stated that most home owners install the showerheads themselves. It is also assumed that this retrofit program will be implemented by enacting an ordinance requiring all homeowners to retrofit their existing showerheads.

The cost of saving one ac-ft of water per year via the installation of low flow showerheads range from $25 to $67, assuming a seven year life expectancy (EQ. 9). An estimated $46 per ac-ft of water per year will be used in developing the marginal cost curve. It is also assumed that 10% of the population already has installed low flow shower-heads.

It should be noted that this is not the only way of implementing this type of program. MCWD has implemented a retrofit showerhead program, whereby the MCWD purchases the low flow showerheads with public funds at wholesale prices ($4.00 per showerhead). They are provided to residents at no cost. The cost of saving one ac-ft water via this program is estimated to be $16.77 per ac-ft.

c. Educational and Public Information Program

The marginal cost of saving one ac-ft of water through educational and public information programs is based on results obtained from the California Water Service Company and Marina County Water district:

1. **California Water Service Company**. During 1990-1991, Cal Water spent approximately $34,000 on water conservation educational and public information programs, including television and radio commercials. The company was also actively involved with the local community government water conservation programs and committees. Cal Water believes that it achieved a 3% reduction in water use per year (equivalent to 414 ac-ft per year) as their customers modified their water consumption habits. Thus, the estimated marginal cost of saving one ac-ft of groundwater per year through an information and education program is $82 (EQ. 10). This 3% percent reduction does not include the water reduction the agency received through low flow showerheads or toilets [Ref. 28].

2. **Marina County Water District**. This agency has projected that it can reduce water consumption by an estimated 42 ac-ft per year (+/- 14 ac-ft) via a public information and education program for a population of 18,000. The annual cost of this program is $14,360. Therefore, the estimated cost of saving one ac-ft per year through public information and education is $342 (EQ. 11)[Ref. 29:p. 20].

The marginal cost of water reduction via an informational and educational programs is greatly affected by economies of scale, as indicated in the preceding data. Cal Water's state-wide information program, which was conducted out of their corporate headquarters, was designed to inform and educate all 350,000 customers in 21 regions of the state. MCWD, on the other hand, has only 18,000 customers. This analysis will use an average of the two estimated marginal

costs as the projected marginal cost of saving one ac-ft of ground water per year up to maximum reduction of 5%. This average marginal cost is $212 per ac-ft per year.

d. Water Reclamation Program

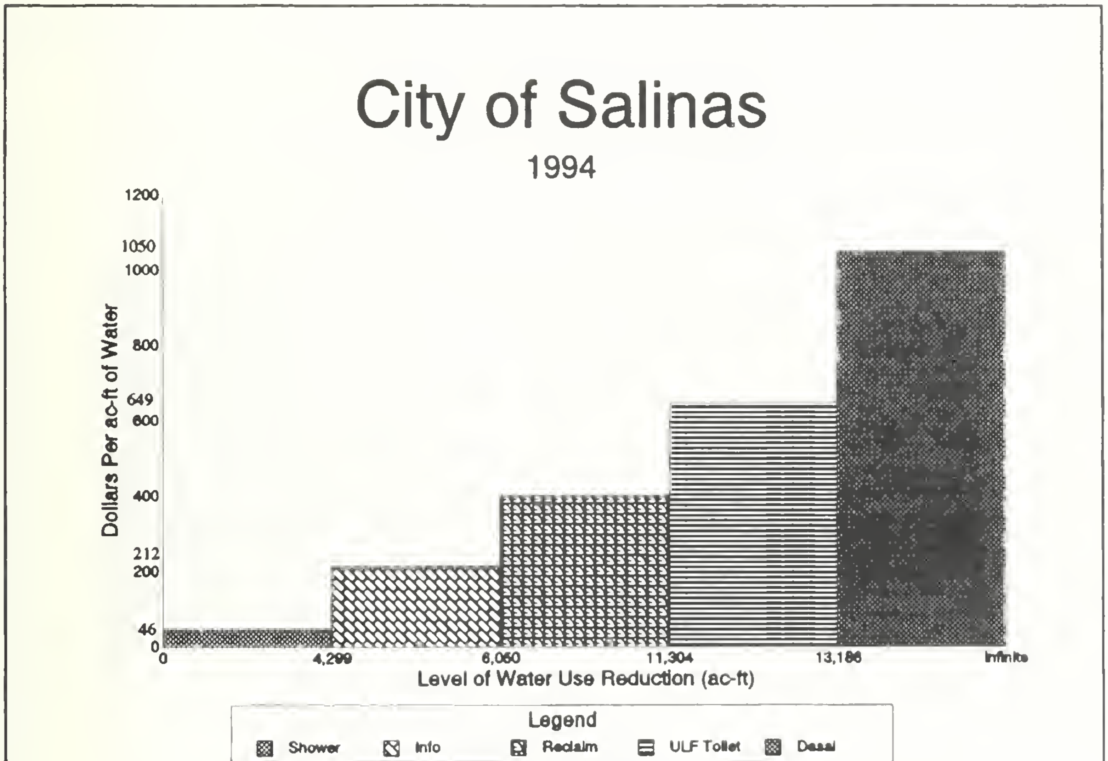
The marginal cost for a water reclamation program was estimated using data from the MCWD reclamation project. The MCWD facility is an advanced wastewater treatment plant which reclaims and treats secondary effluent that is used to irrigate parks, ball fields, median strips and other public landscape areas. The current estimated cost of water from this facility is $400 per ac-ft. The MCWD facility can produce 300 ac-ft per year, which means they can reduce potable water use by 14%, based on 1993 water use data. This analysis will assume that a 15% maximum water use reduction can be achieved through a reclamation program. [Ref. 29:p. vi]

e. Seawater Desalination Program

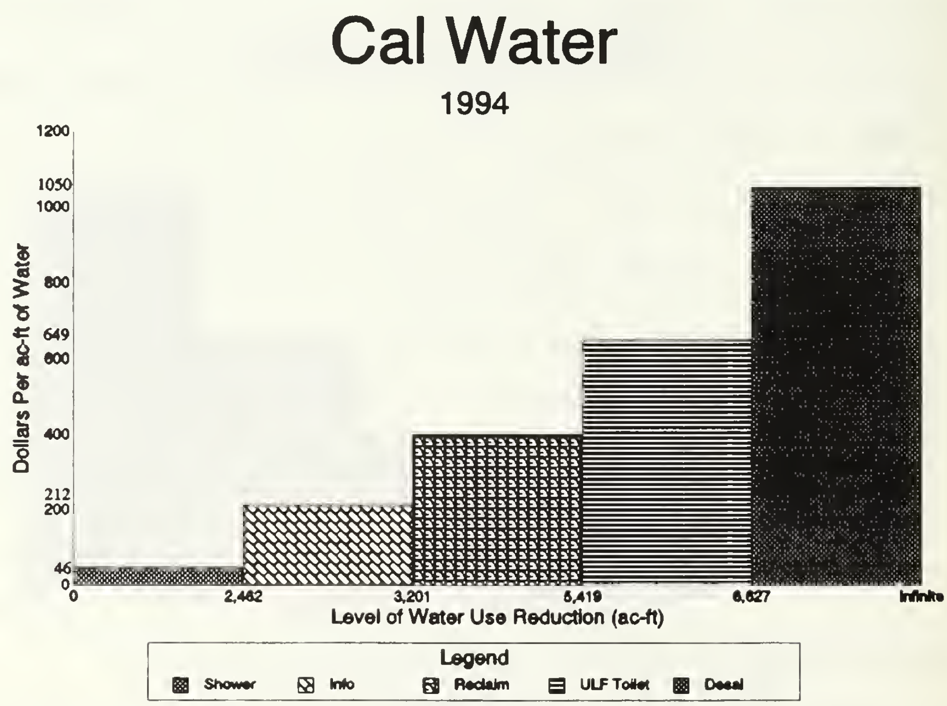
Current estimates for the annual marginal cost of desalinating seawater ranges from $1,000 to $1,100 per ac-ft of water, depending on the plant size and other project elements. This analysis assumes the cost to be $1,050 per ac-ft of water. The most significant obstacle to operating a desalination plant is the disposal of brine discharge. Brine cannot be discharged into the Monterey Bay since it is a marine sanctuary. Brine discharge would have to be pumped to inland evaporation pools or pumped into non-potable oceanside aquifers. [Ref. 29:p. vi]

5. Subsample Representatives' Marginal Cost Curves For Reducing Water Use

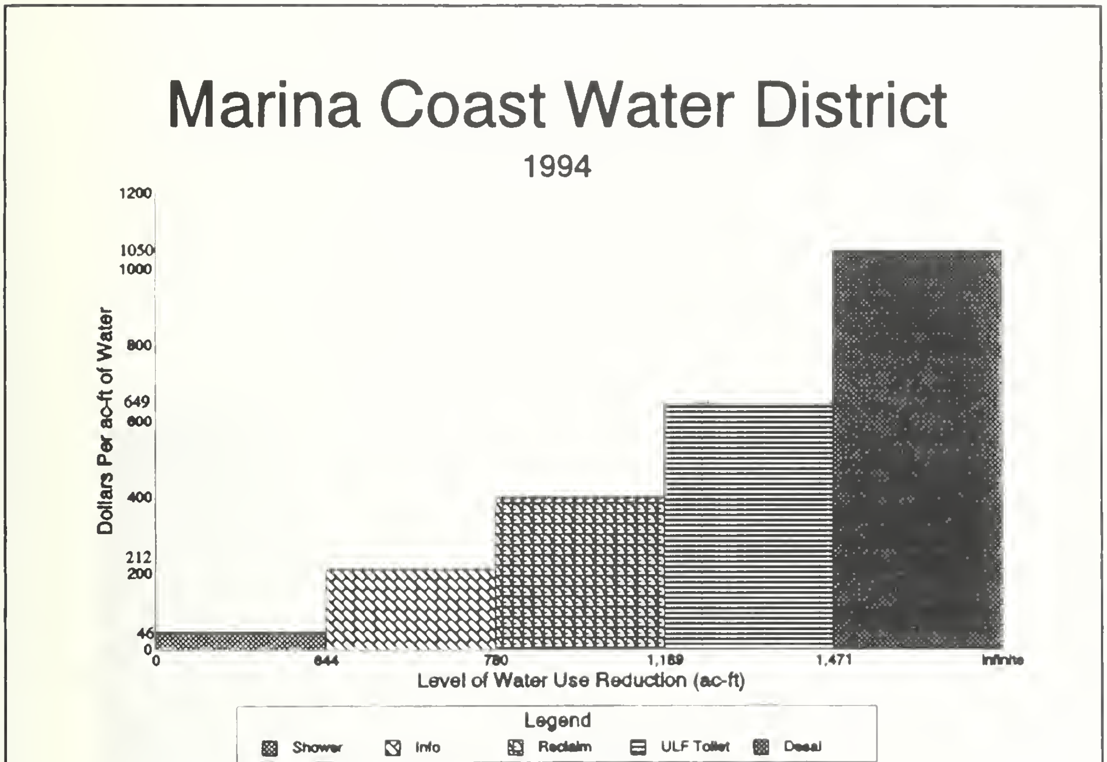
The following marginal cost curves are generated from the preceding analysis for the three urban water districts based on 1994 population and water use data (EQ. 12).



(Calc. 36 thru 39)

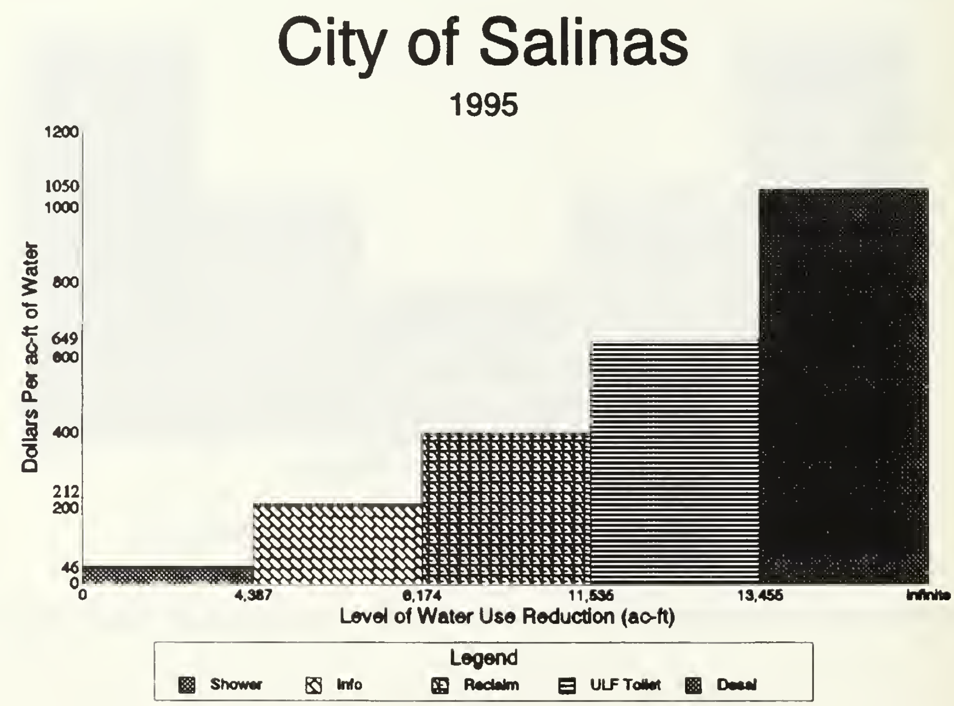


(Calc. 40 thru 43)

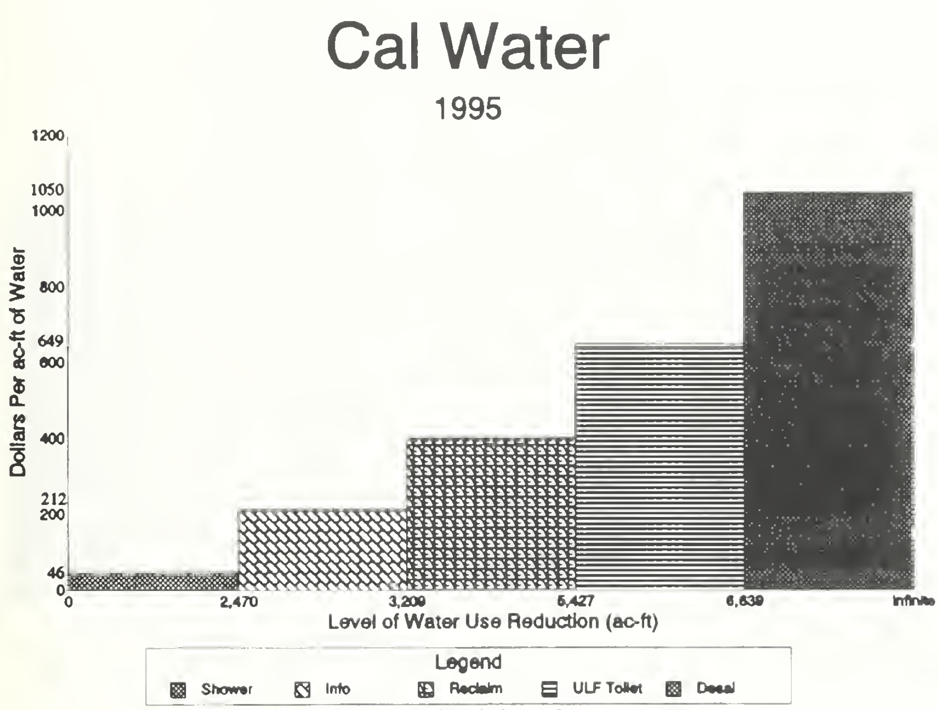


(Calc. 44 thru 47)

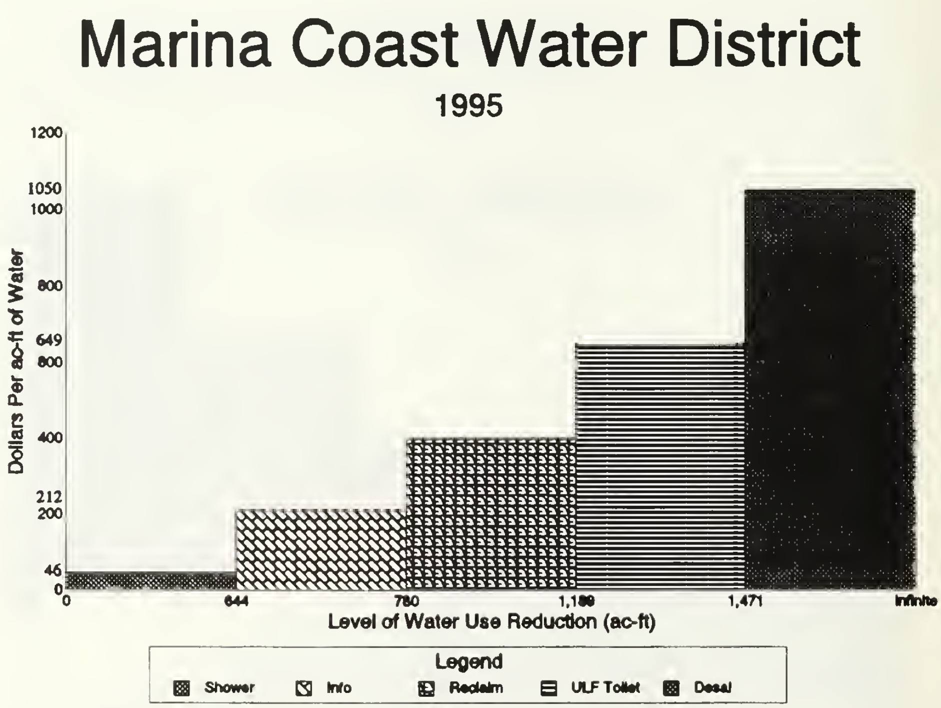
The following marginal cost curves were generated from the preceding analysis using 1995 population and water use data (EQ. 12).



(Calc. 48 thru 51)

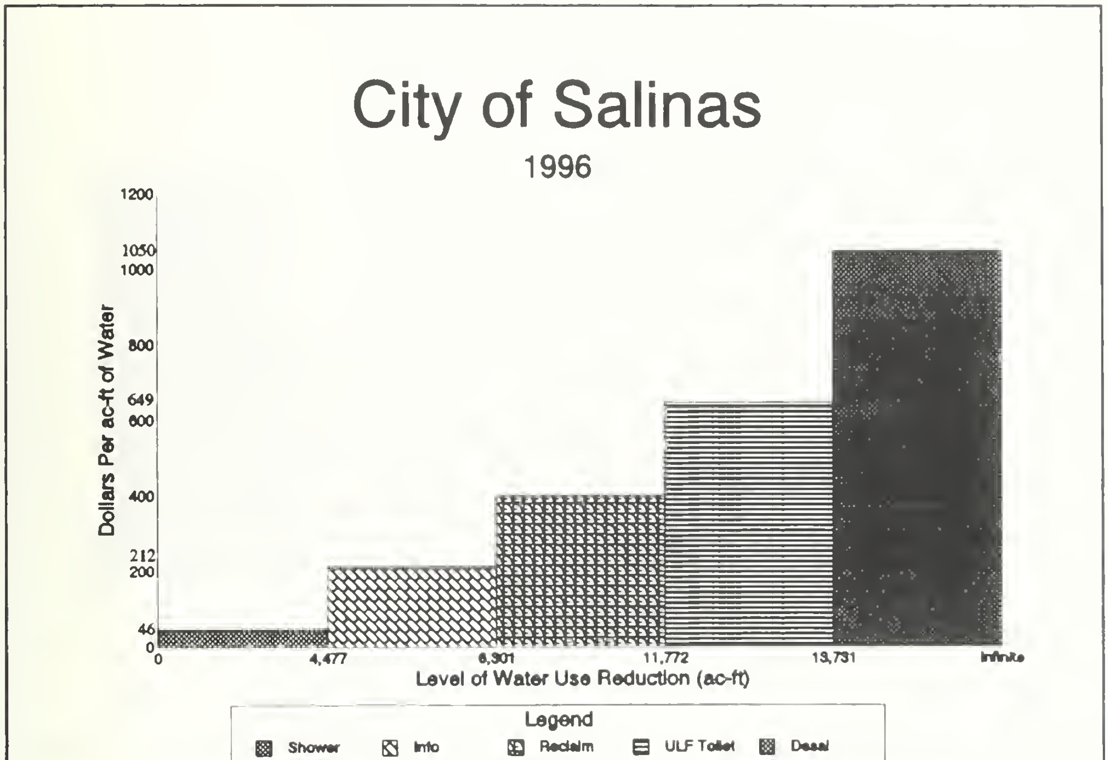


(Calc. 52 thru 55)

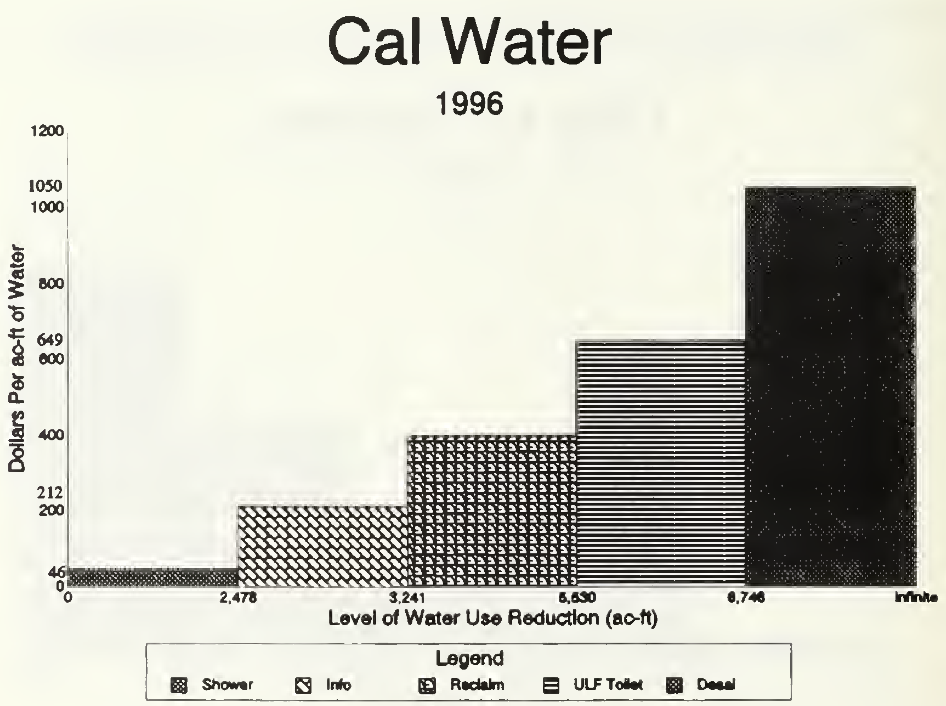


(Calc. 56 thru 59)

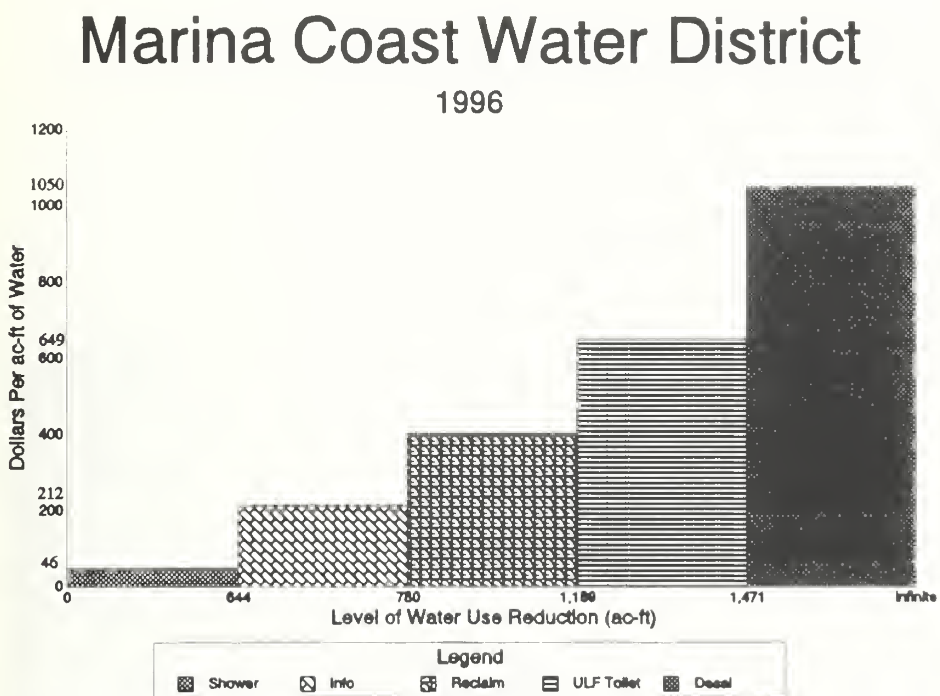
The following marginal cost curves were generated from the preceding analysis using 1996 population and water use data (EQ. 12).



(Calc. 60 thru 63)



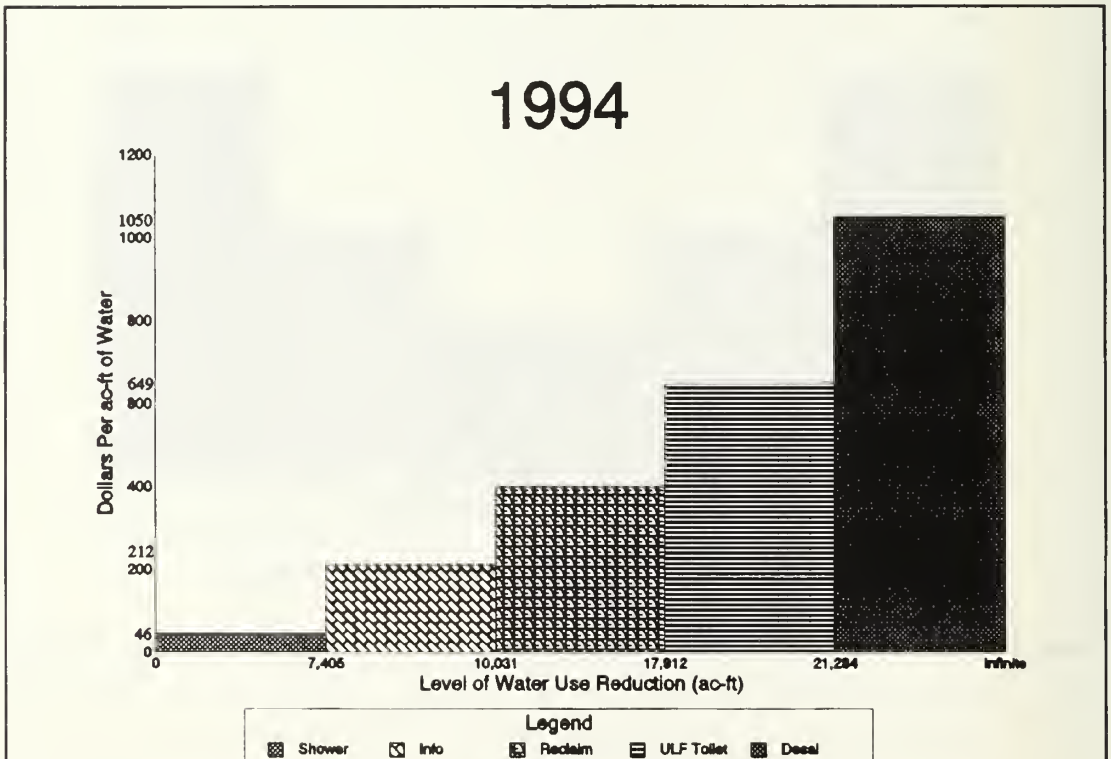
(Calc. 64 thru 67)



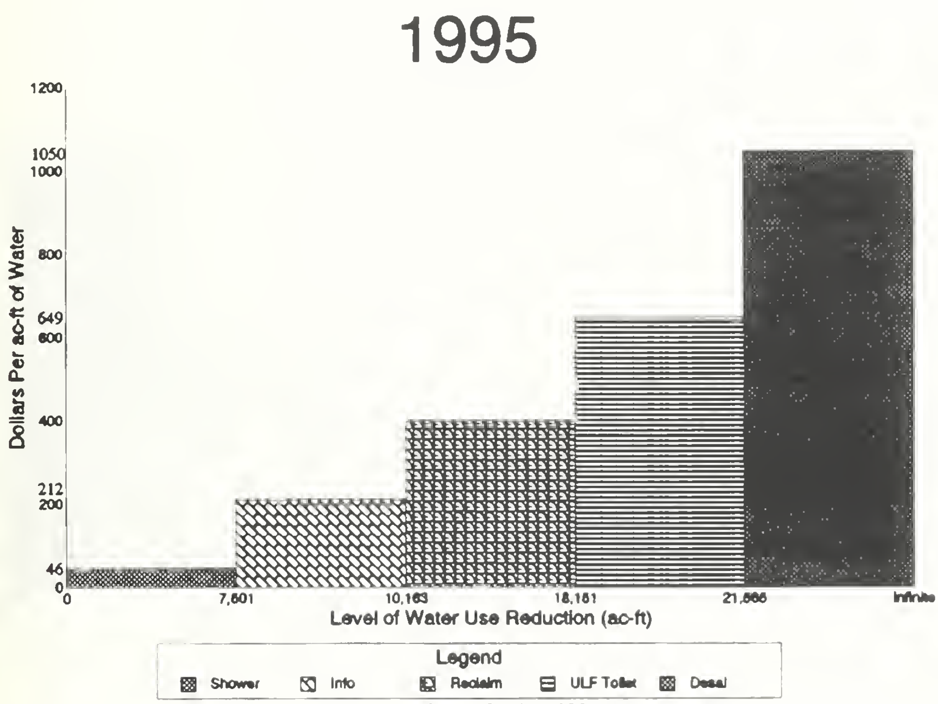
(Calc. 68 thru 71)

6. Urban Sector's Marginal Cost Curve For Reducing Water Use

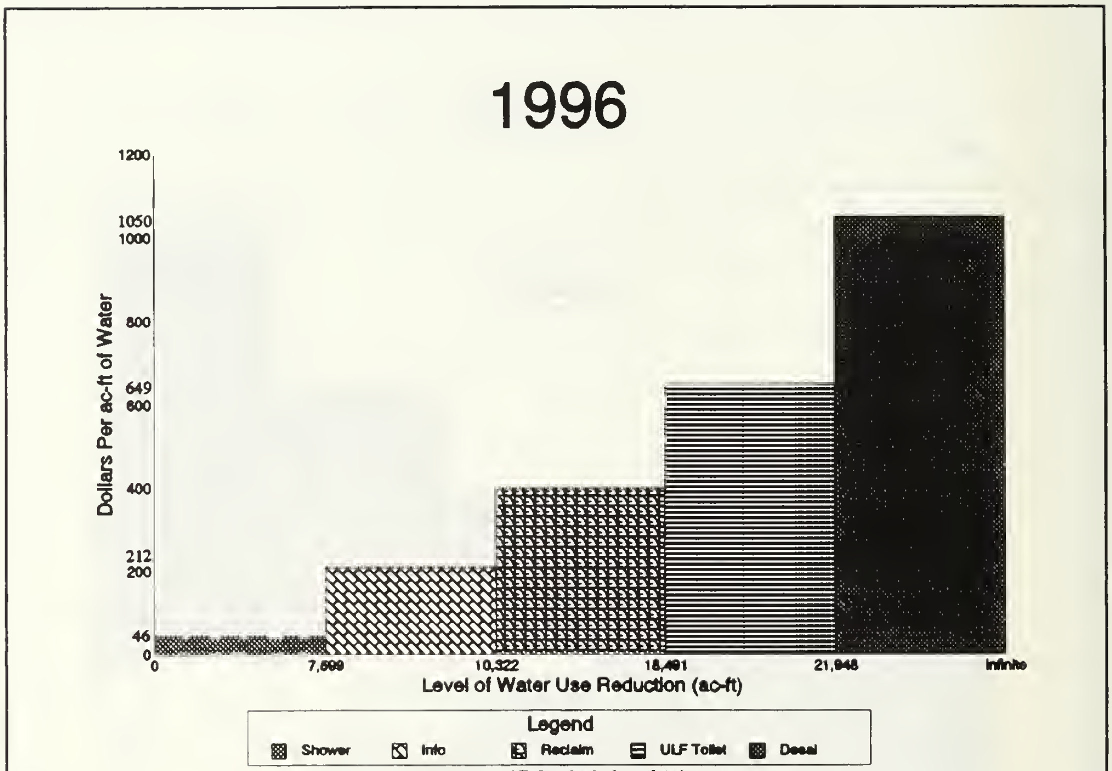
The following marginal cost curves were generated by combining the marginal cost curves for the three urban water districts.



(Calc. 133 thru 136)



(Calc. 137 thru 139)



(Calc. 141 thru 144)

7. Economic Cost of MCWRA Allocation Plan

Table 5-10 presents the economic cost of complying with MCWRA Ordinance No. 03774[23] for the City of Salinas, the California Water Service Company, and Marina Coast Water District. These results are based on the preceding marginal cost curves and the projected required reductions (EQ. 6).

8. Economic Cost of the Thesis Allocation Plan

Table 5-11 presents the economic cost of complying with the free market allocation plan for the City of Salinas, California Water Service Company, and Marina Coast Water District. These results are based on the preceding marginal cost curves and the projected annual shortfall each year as well as the following assumptions.[24]

1. The subsample representative would choose to use the mean of the last five years for their historical use figure. Average water use = AEA = ((FY88 + FY89 + FY90 + FY91 + FY93) / 5).

2. Average net reduction[25] for the zone is equal to the total recharge for the zone divided by the total discharge (ANR = Total Recharge / Total Discharge).

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[23]This ordinance requires a 15% per capita reduction based on the 1987 per capita water use.

[24]This table was created by using equation 7 in Appendix A, and the calculations are shown in Appendix B, line 79 - 132.

[25]Average net reduction is a correction factor which is used to establish the maximum amount of groundwater that can be extracted from that zone and still keep the basin in balance.

TABLE 5-10. URBAN SECTOR COMPLIANCE COST FOR THE MCWRA ALLOCATION PROGRAM

City of Salinas					
YR	Pop.	Projected Water Demanded	Ordinance Limit	Required Reduction	Economic Cost/Yr
94	120,197	35,025	29,772	5,253	$400,002[72]
95	122,655	35,742	30,380	5,362	$408,502[73]
96	125,163	35,742	31,002	5,470	$416,458[74]
1987 Wat./Pop. = .2914					
California Water Service Company					
YR	Pop.	Projected Water Demanded	Ordinance Limit	Required Reduction	Economic Cost/Yr
94	20,188	14,784	12,567	2,217	$101,982[75]
95	20,509	15,019	12,767	2,252	$101,982[75]
96	20,888	15,260	12,972	2,288	$105,248[77]
1987 Wat./Ser. = .7323					
Marina Coast Water District					
YR	Pop.	Projected Water Demanded	Ordinance Limit	Required Reduction	Economic Cost/Yr
94	18,000	2,729	2,320	409	$18,814[78]
95	18,000	2,729	2,320	409	$18,814
96	18,000	2,729	2,320	409	$18,814
1987 Wat./Pop. = .1516					
Total Urban Sector					
YR		Projected Water Demanded	Ordinance Limit	Required Reduction	Economic Cost/Yr
94		52,538	44,659	7,879	$520,798
95		53,490	45,467	8,023	$530,908
96		54,461	46,294	8,167	$540,520

3. The representative's water share allotment in acre-feet is equal to the average net reduction of the zone multiplied by the five year average water use (allotted Annual Extraction Amount (AAEA) = AEA X ANR).

4. Based on the Montgomery Watson Groundwater Model, the total discharge for the valley is 535,000 ac-ft per year and the total recharge for the valley is 498,000 ac-ft per year. Therefore, ANR = 498,000 / 535,000 = .93.

5. Allocation Limit = AAEA = Five year average water use (AEA) X Average Net Reduction (ANR).

6. In calculating the compliance cost for the free market allocation plan, it is assumed that subsample representatives will be able to purchase or sell as much water as they desire at the prevailing market price.

TABLE 5-11. URBAN SECTOR COMPLIANCE COST FOR THE FREE MARKET ALLOCATION PROGRAM

City of Salinas			
YR	**Projected Water Demanded**	**Allocation Limit**	**Shortfall**
96	35,025	30,006	5,019
95	35,742	30,006	5,019
96	36,472	30,006	6,466
Five year average extraction amount (AEA) = 32,264 AC-FT ANR = .93 Allocation limit = AAEA = 32,264 X .93 = 30,006 ac-ft per year			

TABLE 5-11 (CONTINUED)

Economic Cost/YR:

YR	No Water Trades (Regulatory System)	Mkt. Price of Water is $15/ac-ft	Mkt. Price of Water is $30/ac-ft
94	$350,394	$75,285	$150,570
95	$487,790	$40,785	$172,080
95	$658,630	$96,990	$193,980

YR	Mkt. Price of Water is $75/ac-ft	Mkt. Price of Water is $100/ac-ft	Mkt. Price of Water is $200/ac-ft
94	$251,754	$269,754	$341,754
95	$302,977	$336,702	$471,602
95	$355,117	$404,842	$603,742

California Water Service Company

YR	Projected Water Demanded	Allocation Limit	Shortfall
94	14,784	12,300	2,484
95	15,019	12,300	2,719
95	15,260	12,300	2,960

Five year average extraction amount (AEA) = 13,226 AC-FT
ANR = .93
Allocation limit = AAEA = 13,226 X .93= 12,300 ac-ft per year

Economic Cost/YR:

YR	No Water Trades (Regulatory System)	Mkt. Price of Water is $15/ac-ft	Mkt. Price of Water is $30/ac-ft
94	$117,916	$37,260	$74,520
96	$166,408	$40,785	$81,570
96	$216,172	$44,400	$88,800

TABLE 5-11 (CONTINUED)

YR	Mkt. Price of Water is $75/ac-ft	Mkt. Price of Water is $100/ac-ft	Mkt. Price of Water is $200/ac-ft
94	$114,902	$115,452	$117,652
95	$132,295	$138,520	$163,420
96	$150,138	$162,188	$210,388

Marina Coast Water District

YR	Projected Water Demanded	Allocation Limit	Shortfall
94	2,729	2,450	279
95	2,729	2,450	279
96	2,729	2,450	279

Five year average extraction amount (AEA) = 2,634.8 AC-FT
ANR = .93
Allocation limit = AAEA = 2,634.8 X .93 = 2,450 ac-ft per year

Economic Cost/YR:

YR	No Water Trades (Regulatory System)	Mkt. Price of Water is $15/ac-ft	Mkt. Price of Water is $30/ac-ft
94	$12,834	$4,185	$8,370
95	$12,834	$4,185	$8,370
96	$12,834	$4,185	$8,370

YR	Mkt. Price of Water is $75/ac-ft	Mkt. Price of Water is $100/ac-ft	Mkt. Price of Water is $200/ac-ft
94	$2,249	$(6,876)	$(43,376)
95	$2,249	$(6,876)	$(43,376)
96	$2,249	$(6,876)	$(43,376)

$() = negative cost = Profit
= revenue generate by selling excess water generated through water conservation program - water conservation program costs

TABLE 5-11 (CONTINUED)

Total Urban Sector			
YR	**Projected Water Demanded**	**Allocation Limit**	**Shortfall**
94	52,538	44,756	7,782
95	53,490	44,756	8,734
96	54,461	44,756	9,705
Economic Cost/YR:			
YR	**No Water Trades (Regulatory System)**	**Mkt. Price of Water is $15/ac-ft**	**Mkt. Price of Water is $30/ac-ft**
94	$481,144	$116,730	$233,460
96	$667,032	$131,010	$262,020
96	$887,636	$145,575	$291,150
YR	**Mkt. Price of Water is $75/ac-ft**	**Mkt. Price of Water is $100/ac-ft**	**Mkt. Price of Water is $200/ac-ft**
94	$368,905	$378,330	$416,030
95	$437,521	$468,346	$591,646
96	$507,504	$560,154	$770,754

The negative costs for Marina when water prices equal $100 per ac-ft and $200 per ac-ft indicate that Marina actually profits by selling excess water at these prices. With a low flow showerhead retrofit program, Marina can meet their required water reduction and sell enough water to earn a net profit.

9. Comparison of the Costs of the Two Allocation Plans

The proposed free market allocation plan has significantly lower cost of compliance than the MCWRA allocation plan based on the preceding analysis. The range of cost savings[26] that can be achieved in 1994, 1995, and 1996 is summarized in Table 5-12 for each individual water district.

As with the industrial sector, this cost comparison reflects water use reductions as required in each of the two programs. Thus, the water use reduction varies from program to program. Specifically, the MCWRA program requires greater water use reductions than the free market program for the City of Salinas in 1994 and MCWD in all years. The free market program requires greater reductions than MCWRA program for the City of Salinas in 1995 and 1996 and Cal Water in all years. As a result, the cost savings in Table 5-12 reflects both the allocation methodology and the required reduction levels. The cost savings (both positive and negative) in the "No Water Trade (Regulatory System) case indicate the cost implications of the different water reduction levels. The market based plan has lower costs (positive cost savings) in those cases where its required water reductions are lower; it has higher costs (negative cost savings) in those cases where its required water reductions are higher. If both plans required

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[26]The definition of "Cost Savings" for this analysis is the subsample representative's cost of compliance under the MCWRA allocation program minus its cost of compliance under the free market program.

the seawater reductions, they would have identical costs in the "No Water Trade" case.

The other negative costs savings in Table 5-12 also reflect this pattern. As the price of water increases, it becomes more expensive to buy water to satisfy the required reductions. Therefore, negative cost savings are most likely in cases where the market prices are high and the free market based program has higher reduction levels. Table 5-12 shows negative cost savings for the City of Salinas in 1995 and 1996

TABLE 5-12. URBAN SECTOR COST SAVINGS PER YEAR (BASED ON THE FOLLOWING MARKET PRICE OF WATER)

City of Salinas			
YR	No Water Trades (Regulatory System)	Mkt. Price of Water is $15/ac-ft	Mkt. Price of Water is $30/ac-ft
94	$49,608	$324,717	$249,432
95	$(79,288)	$322,462	$236,422
96	$(242,172)	$319,468	$222,478
YR	Mkt. Price of Water is $75/ac-ft	Mkt. Price of Water is $100/ac-ft	Mkt. Price of Water is $200/ac-ft
94	$148,248	$130,248	$ 58,248
95	$105,525	$ 71,800	$ (63,100)
96	$ 61,341	$ 11,616	$ (187,284)

TABLE 5-12 (CONTINUED)

California Water Service Company			
YR	No Water Trades (Regulatory System)	Mkt. Price of Water is $15/ac-ft	Mkt. Price of Water is $30/ac-ft
94	$(15,934)	$64,722	$27,462
95	$(62,816)	$62,807	$22,022
96	$(110,924)	$60,848	$16,448
YR	Mkt. Price of Water is $75/ac-ft	Mkt. Price of Water is $100/ac-ft	Mkt. Price of Water is $200/ac-ft
94	$(12,920)	$(13,470)	$ (15,670)
95	$(28,703)	$(34,928)	$ (59,828)
95	$(44,890)	$(56,940)	$(105,140)
Marina Coast Water District			
YR	No Water Trades (Regulatory System)	Mkt. Price of Water is $15/ac-ft	Mkt. Price of Water is $30/ac-ft
94	$5,980	$14,629	$16,448
95	$5,980	$14,629	$16,448
96	$5,980	$14,629	$16,448
YR	Mkt. Price of Water is $75/ac-ft	Mkt. Price of Water is $100/ac-ft	Mkt. Price of Water is $200/ac-ft
94	$16,565	$25,690	$62,190
95	$16,565	$25,690	$62,190
95	$16,565	$25,690	$62,190
( ) - Negative Cost Savings			

when the price of water reaches $200 per ac-ft and for Cal Water in 1994, 1995 and 1996 when the price of water reaches

or exceeds $75 per ac-ft. This reflects the expected pattern. The reverse is also true. The positive cost savings for the City of Salinas in 1994 and for MCWD in all years are at least partially explained by the free market based program lower reduction levels in these cases.

The graph of the 1994 compliance cost for the urban sector in Figure 5-3 shows the inherent advantage that the free market allocation program has over the MCWRA allocation program in the urban sector. This graph is developed from the urban sector combined marginal cost curves and the required levels of water conservation for 1994. The graph assumes subsample representatives can buy or sell as much water as they like at the going market price. The graph shows two levels of reduced water use for the combined urban sector. One represents the required 1994 reduction for the MCWRA program (7,879 ac-ft per year). The other represents the required 1994 reduction for the free market program (7,782 ac-ft per year). This provides a comparison between programs with the same reduction in water use. When the level of reduction is 7,879 ac-ft per year, the compliance cost for the MCWRA program would be $520,798. The compliance cost of the free market allocation program for this level of reduction is always lower than the MCWRA program's cost. The same relative cost comparison is repeated when the required annual reduction is 7,782 ac-ft per year.

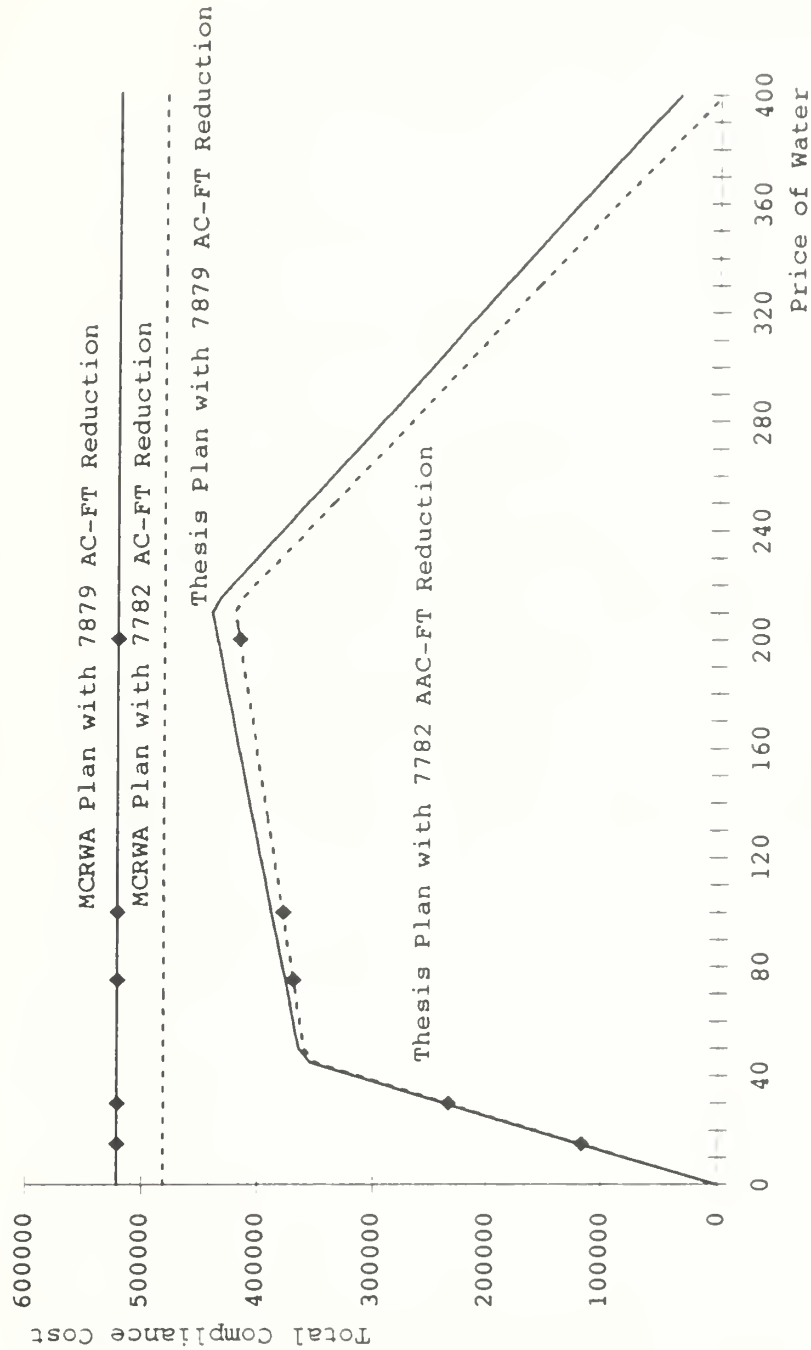

Figure 5-3. Urban Sector Cost Analysis

The MCWRA program specifies reduction levels for each urban water supplier, irregardless of the marginal cost to meet this requirement. Under the MCWRA program, the City of Salinas is forced to conserve 5,253 ac-ft of water in 1994, of which 4,299 ac-ft are conserved through a low flow showerhead retrofit program at $46 per ac-ft and 954 ac-ft are conserved through an information and education program at $212 per ac-ft. MCWD and Cal Water meet their required reductions with only a low flow showerhead retrofit program. Thus, the marginal cost of compliance is higher for the City of Salinas under the MCWRA program. The regulatory program allows cheaper sources of water conservation to go untapped because suppliers cannot buy and sell water.

Under the free market based program, urban users could buy and sell water shares and credits both among themselves and with other industries. Thus, the market based plan will always cost less than the MCWRA program. If the price of water is less than $46 per ac-ft, all urban users would meet their water requirements by purchasing water. If the price of water is between $46 and $212 per ac-ft, all urban sector suppliers would implement a low flow showerhead retrofit program. MCWD and Cal Water would exceed their water reduction requirements and sell their excess water[27] on the

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[27]Excess water is defined as the amount of water that can be conserved which is in excess of required level of conservation. In this case, MCWD has the ability to conserve 644 ac-ft of water annually at $46 per ac-ft through its low

open market; City of Salinas would not satisfy its required reduction, so it would continue to purchase some water from the market. However, the City of Salinas' purchases are less expensive than the alternative: implementing an information and education program. If the market price of water exceeds $212 per ac-ft, all three suppliers could profit by implementing an information and education program and selling their excess water. This would further reduce the sector's total compliance costs. Thus, the cost to each supplier and the total sector's cost are lower for the proposed free market program than for the MCWRA program at all water prices.

D. AGRICULTURAL SECTOR COST ANALYSIS

The agricultural sector cost analysis is based on sixteen farms located near the following cities: Greenfield, Soledad, Gonzales, Salinas, Castroville and Chualar. These farms were selected based on their ability to provide historical data on four crops: lettuce, celery, cauliflower, and broccoli. These crops were chosen because they are four largest sources of revenue for the county in the vegetable crop category [Ref. 7:p. 30]. This category accounts for 71.5% of the gross

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flow showerhead retrofit program. The MCWRA program requires the MCWD to conserve 409 ac-ft per year. Therefore, 235 ac-ft of water is in excess (235 = 644 - 409). Cal Water has the ability to conserve 2,462 ac-ft of water annually at $46 per ac-ft through its low flow showerhead program. MCWRA requires Cal Water to conserve 2,217 ac-ft per year. Thus, 245 ac-ft of water is in excess. The total amount of excess water available from MCWD and Cal Water is 480 ac-ft per year.

revenue generated by the agricultural sector of the Monterey County [Ref. 7:p. 38]. The historical data included acreage planted, yield and growing and packing costs per acre. Farms do not have accurate water use data, so this analysis assumes that each farmer uses on average 2.59_{145} ac-ft of water annually per acre of crop. This figure is the average annual water use per acre of crop for the Salinas Valley and is based on the Montgomery Watson groundwater model. Table 5-13 summarizes the data collected from these farms. Note that only averages are shown. This protects the identity of each farm and its proprietary information.

TABLE 5-13. AGRICULTURAL ANALYSIS FOR THE PERIOD 1988 - 1993

ACRES				
	Lettuce	Celery	Cauliflower	Broccoli
Ave. Grower 1998	729	131	203	146
Ave. Grower 1989	664	121	187	164
Ave. Grower 1990	717	141	203	165
Ave. Grower 1991	655	133	203	212
Ave. Grower 1992	717	155	188	234
Ave. Grower 1989	664	131	188	233
Ave. Grower 1988-93	694	135	187	192
% of Ave. Total	57%	11%	16%	16%
Ave. Total Acreage For the Sample Group	**11,104**	**2,160**	**3,104**	**3,072**

TABLE 5-13 (CONTINUED)

YIELD (No. of Cartons per acre)

	Lettuce	Celery	Cauliflower	Broccoli
Ave. Grower 1989	753	1220	693	611
Ave. Grower 1989	785	1190	614	618
Ave. Grower 1989	767	1178	693	740
Ave. Grower 1991	773	1161	654	621
Ave. Grower 1992	751	1154	702	649
Ave. Grower 1989	814	1170	706	647

1 Carton = 50 pounds

GROWING COST PER ACRE($)

	Lettuce	Celery	Cauliflower	Broccoli
Ave. Grower 1989	1664	3079	1928	1444
Ave. Grower 1989	1743	3051	1976	1467
Ave. Grower 1992	1806	3091	2014	1625
Ave. Grower 1991	1912	3260	2122	1625
Ave. Grower 1992	1989	3407	2014	1751
Ave. Grower 1993	2117	3559	2306	1822

NET PROFIT AFTER PACK AND GROW COSTS (Total in $)

	Lettuce	Celery	Cauliflower	Broccoli
Ave. Grower 1989	-69	252,223	-42,297	-15,804
Ave. Grower 1989	269,365	116,707	-34,367	-37,749
Ave. Grower 1992	479,852	19,512	2,992	21,858
Ave. Grower 1991	228,452	-62,735	-87,206	-22,248

TABLE 5-12 (CONTINUED)

	Lettuce	Celery	Cauliflower	Broccoli
Ave. Grower 1992	270,809	116,309	2,326	30,018
Ave. Grower 1993	220,397	-96,168	-97,948	-36,131
NET PROFIT PER ACRE ($)				
	Lettuce	**Celery**	**Cauliflower**	**Broccoli**
Ave. Grower 1988	-.09	1,925	-208	-105
Ave. Grower 1989	669	965	-184	-200
Ave. Grower 1990	669	138	15	132
Ave. Grower 1988	349	- 472	-430	-105
Ave. Grower 1990	366	750	12	128
Ave. Grower 1990	336	- 734	-538	-105
Six Year Ave. **2/3 Trimmed Mean:**	**$354** **$364**	**$ 429** **$ 345**	**- 222** **-$203**	**- 56** **-$60**

Each irrigation methods' efficiency has not yet been measured in the Salinas Valley.[28] The MCWRA estimates that

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[28]Irrigation efficiency (IE) is a measure of the proportion of water applied that is actually used beneficially [Ref. 5:p. 4].

IE = (Water Beneficially Used) / (Total Water Applied)

Where beneficial uses include water necessary for:
* crop transpiration
* salinity control
* climate control (frost protection and crop cooling)

and non-beneficial uses include:
* application losses such as spray drift or uncollected run-off
* evaporation from wet soil surfaces or wet foliage
* deep percolation of water past the root zone (in excess of the leaching requirements)

the irrigation efficiency (IE) for all crops and all irrigation methods is 64% [Ref. 21]. However, the MCWRA Mobile Lab and the University of California's Cooperative Agricultural Extension in Salinas evaluated the distribution uniformities (DU) for various farm irrigation systems in the Salinas Valley during the period 1990 - 1992.

Distribution uniformity is a measure of how evenly an irrigation system applies water to all plants in a field. If water is not applied evenly, portions of a field may be under-irrigated and/or over-irrigated. If distribution uniformity is low, a field can be irrigated sufficiently only if excessive water is applied. Non-uniform water application (low DU) is one of the main limitations to achieving high on-farm irrigation efficiencies. [Ref. 5:p. 4]

This distribution uniformity is equal to irrigation efficiency (not accounting for application losses) when the amount of beneficially used water is the same as the average amount infiltrated in the low quarter. Therefore, "DU may be considered as the maximum potential IE of a properly managed irrigation system, if under-irrigation is to be avoided." [Ref. 5:p. 6]

Distribution uniformity is defined as DU = (low 1/4) / (Average). The lower 1/4 is the average depth of water infiltrated in the 25 percent of the study area receiving the least amount of water; average is the average depth of water

infiltrated in the entire study area [Ref. 5:p. 6]. Table 5-14 summarizes the findings [Ref. 5:p. 7].

TABLE 5-14. DISTRIBUTION UNIFORMITY

System Type	No.	Min	DU (%) Max	Average
All Systems	103	27	93	68
Sprinkler	39	41	88	68
Linear Move	10	62	88	74
Drip (Vines)	3	49	93	69
Drip Tape (all)	26	27	92	64
Berries	13	27	86	60
Row-Crop	13	46	92	68
Furrow	25	27	88	66

This analysis will assume that the irrigation efficiency of each irrigation method in the valley is the same as its DU as shown in Table 5-14. This assumption generally agrees with the historical irrigation efficiency data presented in Chapter II.

The cost of upgrading a existing furrow irrigation system to sprinkler or linear irrigation system is based on a telephone interview conducted on May 6, 1994 with a Salinas Valley irrigation supplier and rental company (Rain for Rent, Inc.). Per this telephone conversation, there is no cost savings from having a pre-existing irrigation system. Very little of the existing system's material can be used in the new system. Therefore, the cost of upgrading equals the cost

of purchasing and installing a new irrigation system. Tables 5-15 and 5-16 show the data that will be used to estimate the marginal cost curve for reducing water use in agricultural sector.

TABLE 5-15. IRRIGATION SYSTEM COSTS PER ACRE

Type	Service Life (SL)	Cost per Acre (CA)	IE	CA/SL
Linear	10 Yrs	$531	74%	$65.46
Sprinkler	10 Yrs	$300	67%	$36.98
Furrow	10 Yrs	$100	66%	$12.33
IE = DU (from Table 5-13)				
CA/SL = The equivalent uniform annualized cost per year, per acre, of the capital investment[29] for the indicated irrigation system. (EQ. 4, & Calc. 146)				

TABLE 5-16. ANNUAL COST PER AC-FT OF WATER SAVED BY UPGRADING THE IRRIGATION SYSTEM FROM FURROW

Type	Increased Capital Investment Cost Per Acre	Cost per ac-ft of Water Saved per Year per Acre
Linear	$53.13	$\$256.42_{163}$
Sprinkler	$24.65	$\$951.74_{164}$

[29]The capital investment is equal to the cost of initial purchase and installation of the system. But, it does not include the annual operational and maintenance cost of the system.

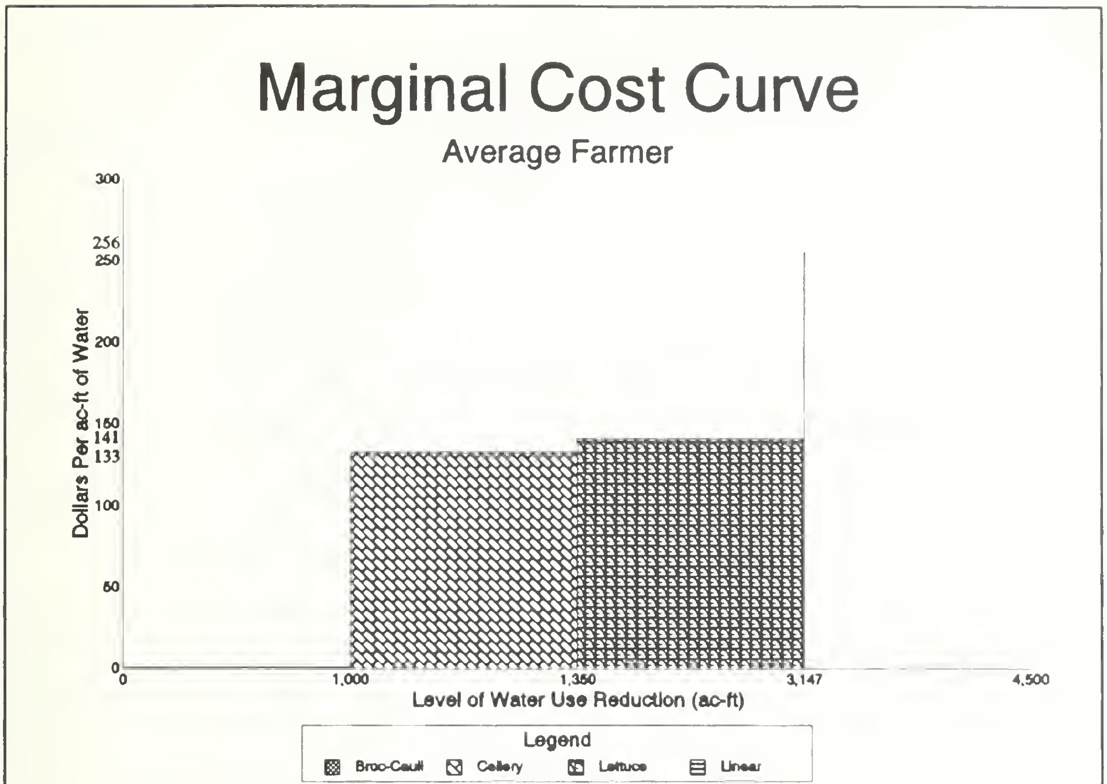
1. Marginal Cost Curve for Reducing Water Use for an Individual Farmer

The following marginal cost curve uses the preceding cost for upgrading the irrigation system. The gross profit[30] analysis for each crop is based on its historical two-thirds trimmed mean. The following assumptions were also made:

1. Water use per acre for a furrow irrigation system is 2.59 ac-ft per year.
2. The average farmer has 1215 acres in production and his crop mix is:
   a. 694 acres of lettuce
   b. 135 acres of celery
   c. 194 acres of cauliflower
   d. 192 acres of broccoli
3. The average farmer is using a furrow irrigation system and would upgrade to a linear move irrigation system since it has the lowest marginal cost of reducing water use.
4. Farmers would opt to remove crops from rotation rather than upgrading the irrigation system if their profit per ac-ft is less than the cost per ac-ft of the upgrade.
5. The average farmer will be referred to as "the farmer" for the purpose of this section.

The average profit per ac-ft of water for all crops in this subsample is lower than the cost per ac-ft of upgrading the irrigation system. Thus, farmers would choose to remove crops out of production before upgrading the irrigation system. In particular the farmer in this subsample would

[30]Gross profit is the difference between sales revenue and production costs.



(Calc. 148 thru 149,& 150 thru 152)

choose not to grow broccoli and cauliflower in order to sell the water saved if the price of water is between $0 and $133 per ac-ft. If the price of water is between $133 and $141 per ac-ft, the farmer would not grow celery in order to sell the water normally used on this crop. If the price of water exceeds $141 per ac-ft farmers would sell all their water rights and grow no crops.

It must be understood that this curve is based on the averages observed in the sample. Individual marginal cost curves can vary greatly from this average. Some farmer's marginal cost curves may justify the upgrading of the irrigation system before taking crops out of production.

2. Projected Allowed Water Use Under the MCWRA Program and Economic Cost Per Year

The following table (5-18) present the projected average allowed water use and economic cost per year for an average farmer in the sample under the MCWRA Ordinance No. 3735. This ordinance establishes upper limits on the amount of groundwater that can be extracted for irrigation purposes. The limit is based on the location, acreage of irrigated crop land, and crop type. Table 5-17 shows the current pumping limits (MCWRA Ordinance No. 3735).

To determine the average farmer's projected annual water demand, the ordinance limit, the required reduction and

TABLE 5-17. UPPER PUMPING LIMITS PER ACRE OF CROP LAND (IN AC-FT PER YEAR)

SUBAREA	TYPE "A" CROPS	TYPE "B" CROPS	TYPE "C" CROPS
P1	2.33	4.00	1.67
P2	2.56	4.00	1.84
E1	2.84	4.22	1.75
E2	3.00	4.44	2.17
P3	3.23	4.44	2.25
FB	3.89	5.11	2.83
UV	4.11	5.33	3.00

Type "A" Crops = Vegetables, Field, Berries, Trees, Forage
Type "B" Crops = Nursery
Type "C" Crops = Grapes

P1 through P3 are subareas of the Pressure Area
E1 and E2 are subareas of the Eastside Area
FB = Forebay Area
UV = Upper Valley Area

TABLE 5-18. SUMMARY OF AGRICULTURAL COMPLIANCE COSTS FOR THE MCWRA ALLOCATION PROGRAM

SUMMARY OF AGRICULTURAL ACREAGE (ACRES)					
Year	Pressure (P1,P2,P3)	Eastside (E1,E2)	Forebay (FB)	Upper Valley (UV)	Total
1991	52,327	36,437	57,791	51,272	197,827
%	26.45%	18.42%	29.21%	25.92%	

HISTORICAL AVERAGE FARMER'S WATER USE AND COST OF COMPLIANCE UNDER THE MCWRA PROGRAM					
Year	AC	Projected Water Demanded	Upper Pumping Limit	Surplus Irrigation Capacity	Compliance Cost Per Year
1988	1209	3,131	4,177	1,046	$0
1989	1136	2,942	3,925	983	$0
1990	1226	3,175	4,236	1,061	$0
1991	1203	3,116	4,156	1,040	$0
1992	1317	3,411	4,550	1,139	$0
1993	1202	3,113	4,153	1,040	$0
Average:	1,215	3,147	4,198	1,051	$0
Sample Total:	19,400	50,350	67,165	16,815	$0

PROJECTED WATER USE AND ECONOMIC COST PER YEAR FOR AVERAGE FARMER					
Year	AC	Projected Water Demanded	Upper Pumping Limit	Surplus Irrigation Capacity	Compliance Cost Per Year
1994	1215	3,147	4,198	1,051	$0
1995	1215	3,147	4,198	1,051	$0
1996	1215	3,147	4,198	1,051	$0

the annual cost of complying with the MCWRA's allocation program (EQ. 6), this analysis assumes:

1. The projected annual demand per acre is 2.59 ac-ft. This figure is the average water use per acre of irrigated crop land according to the Montgomery Watson groundwater model.

2. The annual upper pumping limit per acre for an average farmer in the valley is 3.455_{147} ac-ft. This is a weighted average of the authorized pumping limit for type "A" crops. It is based on the 1991 distribution of crop land between the four hydrological regions (See Table 5-18) [Ref. 2:p. 4-13].

3. The level of crop production and acreage remains constant for 1994, 1995 and 1996.

3. Projected Allowed Water Use Under the Free Market Program and Economic Cost Per Year

Tables 5-19 presents the allowed water use and the annual cost of compliance for the average farmer based on the proposed allocation program, the agricultural marginal cost of compliance curve and the projected shortfall. Table 5-20 presents that same data for the agricultural subsample as a whole. The projections for the free market program are based on the following assumptions:

1. The farmers would choose to use the mean of the last five years for their historical use figure. Average water use = AEA = ((FY88 + FY89 + FY90 + FY91 + FY93) / 5).

2. The average net reduction for the zone is equal to the total discharge for the zone divided by the total discharge (ANR = Total Recharge / Total Discharge).

3. Based on the Montgomery Watson Groundwater Model, the total discharge for the valley = 535,000 ac-ft per year and the total recharge for the valley = 498,000 ac-ft per year. Therefore, ANR = 498,000 / 535,000 = .93.

TABLE 5-19. AN INDIVIDUAL FARMER'S COMPLIANCE COST FOR THE FREE MARKET ALLOCATION PROGRAM (EQ. 7, CALC. 158-162)

Acreage	Projected Water Demanded	Authorized Limit	Shortfall Per Year
1215	3,147	2,927	220
Economic Cost/Year:			
	No Water Trades (Regulatory System)	Mkt. Price of Water is $15/ac-ft	Mkt. Price of Water is $30/ac-ft
	$0	($11,700)	($23,400)
	Mkt. Price of Water is $75/ac-ft	Mkt. Price of Water is $100/ac-ft	Mkt. Price of Water is $200/ac-ft
	($58,500)	($78,000)	($286,209)
$ () = negative cost = Profit			

4. The AEA is 2.59 ac-ft per year per acre which is the average water use per acre of irrigated crop land given by the Montgomery Watson groundwater model.

5. The average farmer water share allotment in acre-feet would be equal to the average net reduction of the zone multiplied by the historical average water use (allotted Annual Extraction Amount (AAEA) = AEA X ANR).

   Authorized Limit = AAEA = 2.41 ac-ft/yr = 2.59 ac-ft/year X .93.

6. The cost of compliance for the free market allocation plan assumes that subsample representatives will be able to purchase or sell as much water as they desire at the prevailing market price.

7. All crops that have historically negative profit margin will be assumed to have zero profit margin for this analysis.

8. The acreage of crop production will stay constant in the future. Therefore, an average farmer will have 1,215 acres of crop land under production each year based on data collected from the agricultural sample.

TABLE 5-20. AGRICULTURAL SECTOR COMPLIANCE COSTS FOR THE FREE MARKET ALLOCATION PROGRAM (1994-1996) (EQ. 7, CALC. 153-157)

Acreage	Projected Water Demanded	Authorized Limit	Shortfall Per Year
19,440	50,352	46,832	3,520
Economic Cost/Year:			
	No Water Trades (Regulatory System)	Mkt. Price of Water is $15/ac-ft	Mkt. Price of Water is $30/ac-ft
	$0	($187,200)	($374,400)
	Mkt. Price of Water is $75/ac-ft	Mkt. Price of Water is $100/ac-ft	Mkt. Price of Water is $200/ac-ft
	($936,000)	($1,248,000)	($4,579,344)
$ () = negative cost = Profit from reducing crop acreage and selling the excess water.			

4. Economic Cost Comparison of the Two Allocation Plans

The preceding analysis shows that the free market program creates a potential revenue stream for the farmers in the sample. Cauliflower and broccoli have had a negative average profit for the sample of farmers over the last six years. The water used on these crops could be sold on the open market. The proposed free market program can profit the agricultural sample group even though it requires a greater water reduction than the MCWRA allocation program.

This analysis also indicates that the farming community would lose its economic incentive to farm if the market price of water exceeds $140.54 per ac-ft. This is profit

margin per ac-ft of water for the most profitable crop, lettuce.

VI. CONCLUSION

This thesis examines the advantages and disadvantages of three ways to allocate groundwater. It also determines if a free market allocation program is more economically efficient than the MCWRA allocation program for the Salinas Valley. The thesis covered four areas:

1. The groundwater resource problems in the SVGB and the Valley's historical land and water use trends in the agricultural and the urban sectors were discussed. The urban sector analysis was divided into five segments: industrial, residential, commercial, agricultural, and governmental. Background material was presented on the MCWRA's mission and legal authority and the steps they have taken to solve the groundwater resource problem.

2. The advantages and disadvantages of three basic allocation systems were analyzed. The three systems are: the regulatory control system (maximum consumption limits); the taxation allocation system (consumption fee); and the free market allocation system (transferable consumption rights).

3. A privatization plan for the SVGB was proposed. Each of the plan's program elements were identified and analyzed for feasibility. A proposed organizational structure was also analyzed.

4. The compliance costs were estimated for two allocation plans (MCWRA's plan and theoretical free market (privatization) plan), based on a sample group of water users from the industrial, urban and agricultural sectors. The initial start-up and annual operating costs of both allocation plans were also estimated.

The conclusions drawn from each component will be discussed in the following sections.

A. SVGB GROUNDWATER RESOURCES PROBLEM

The SVGB has historically been overdrafted by 37,000 ac-ft of water annually (See Table 2-8). Evidence shows that the basin's groundwater levels have been constantly declining since 1945 (see Figure 2-7). The groundwater currently required by the basin's agricultural, urban and industrial water users is greater than the basin's natural recharge rate. This condition, if not corrected, will continue and possibly accelerate. Data presented in Chapter II indicates that the urban sector is projected to continue increasing its demand for water through the year 2020 (See Table 2-2, 2-3, 2-4, 2-5,and 2-6). Agricultural water demand will probably remain constant, or decrease slightly, as small portions of farmland are annually converted into urban uses.

Overdrafting of the basin has caused several documented problems:

1. The cost of extracting groundwater from the basin has increased as the water table lowers. This has also permanently damaged the basin's storage capacity because parts of the water bearing semiconsolidated sediments have been irreversibly compacted.

2. Overdrafting in the Pressure Area has accelerated seawater intrusion into the basin's aquifers along the coast [Ref. 1:p. 31]. Seawater intrusion poses a serious, imminent threat to the municipal water supply for the City of Salinas and other costal communities.

3. Nitrate Contamination in the SVGB is believed to occur when the agricultural community over-irrigates their crops. Over-irrigation enables nitrate laden water to percolate deep into the aquifer system, reducing the basin's water quality.

The MCWRA has taken several steps to reduce overdrafting in the SVGB:

1. The MCWRA established the Salinas River Basin Management Plan (BMP)/program to develop and construct alternative water supplies for the Salinas Valley.

2. The MCWRA has executed a water demand management allocation plan by implementing the following programs:

   a. Voluntary educational programs to promote water conservation methods/programs and improve irrigation efficiency (i.e., the Mobile Irrigation Laboratory program; the California Irrigation Management Information System (CIMIS), the Water Awareness Committee of Monterey County, etc.)

   b. A regulatory control system (maximum consumption standards) for allocating groundwater in the Basin. This was implemented by a series of ordinances regulating maximum agricultural water use by crop type and mandating urban water conservation targets.

   c. A groundwater extraction charge to finance the BMP program and provide economic incentives for well owners to conserve water.

These programs are within the MCWRA's legal authority, as conferred by the State of California. This includes authority to:

1. Regulate urban and agricultural water use by setting upper pumping limits and mandatory water conservation requirements. (MCWRA Ordinance No. 03744 and 03720)

2. Monitor pumping on all Salinas Valley wells having a discharge pipe with a diameter of 3 inches or greater. Well owners are required to purchase and install flowmeters on their wells, and to report annually their groundwater pumping activity to the MCWRA. (MCWRA Ordinance No. 3717)

3. Levy a surcharge on well owners, based on the amount of groundwater they extract from the basin. The charges are incremental and increase as the quantity of water pumped increases above the relevant upper pumping limit. (MCWRA Ordinance No. 3742)

B. ALLOCATION SYSTEM ANALYSIS

The economic, legal and operational advantages and disadvantages of three basic allocation systems for the SVGB were also examined. The major findings for each allocation program are presented in the following tables:

TABLE 6-1. FREE MARKET ALLOCATION METHOD

Advantages:	Disadvantages:
1) Commonly accepted by the economic community as the most economically efficient of the three basic methods.	1) The government lacks knowledge and experience in using this allocation method.
2) Creates profit incentive to conserve water and develop new water conservation technology and methods.	2) This allocation method does not inherently generate revenues to cover monitoring and enforcement costs unless MCWRA collects surcharges on water share trades or collects fines for program violations.
3) Allocates groundwater on the basis of the most valuable use of water at that time.	
4) Compatible with existing legislation.	
5) Minimizes political involvement (compared to the other two allocation systems).	

TABLE 6-2. TAXATION ALLOCATION METHOD (CONSUMPTION FEE)

Advantages:	Disadvantages:
1) Cost avoidance creates an incentive to conserve water, and develop new water conservation technology and methods.	1) Economic inefficiencies can be generated by giving subsidies and waivers to special interest groups for political reasons.
2) The allocation method generates a positive revenue stream for the MCWRA.	2) It is politically difficult to change the surcharge once it has been established.
3) This allocation method is relatively easy to monitor and enforce.	
4) The government has prior experience and existing legislation for this type of allocation method.	
5) This allocation method will generally have a greater economic efficiency compared to a regulatory control allocation method (maximum consumption standards) given that both reduce water use to the same level.	

TABLE 6-3. REGULATORY CONTROL ALLOCATION METHOD (MAXIMUM CONSUMPTION LIMITS)

Advantages:	Disadvantages:
1) Historically, the most widely used method to allocate water in the United States.	1) The marginal costs of reducing water consumption vary greatly among different consumers.
2) Easy to implement due to prior governmental experience and existing legislation.	2) There is no economic incentive to conserve water beyond the authorized upper pumping limit.
3) Neutral financial impact; revenue collected from fines can offset administrative costs.	3) Has the greatest possibility for politically motivated economic inefficiencies.
4) The MCWRA would retain complete control over the use and allocation of groundwater in the basin.	4) It is politically difficult to change the pumping limit once it has been established.
5) Creates an incentive for well owners to invest in water conservation technology and methods when their demand for water is greater than the authorized limit.	

C. FREE MARKET (PRIVATIZATION) ALLOCATION PROGRAM

The third component of this thesis described a free market allocation program for the SVGB. It was patterned after the Reclaim program that is managed by the South Coast Air Basin.

The proposed program uses water credits (units of ownership for water stored in the basin) and shares (units of ownership for the recharge water that flows into the basin) to transfer water consumption rights between private parties.

The best method to initially the allocate water stored in the basin is to allocate it to the MCWRA as water credits. The agency may then sell or transfer these credits to private parties. The best method to allocate water shares is based on historical water use for urban and industrial well owners. For agricultural well owners, the easiest and fairest way of allocating water shares is based on either total acreage owned or acreage being farmed.

The most efficient way to trade water credits and shares is to operate a system similar to the NASDAQ stock exchange. Buyers and sellers of credits and shares would place orders which the MCWRA would execute. A computerized system would track these transactions and monitor the participants' pumping activity.

D. RELATIVE COMPLIANCE COSTS

Finally, this thesis analyzed the compliance and implementation costs for both the MCWRA allocation program and the proposed free market (privatization) program. The analysis sampled representatives from the industrial, urban and agricultural sectors. The industrial representative is the J. R. Smucker Company. The urban representatives include the

City of Salinas, the Marina Coast Water District and the California Water Service Company. The agricultural sector representatives include 16 farms located in the following areas: Greenfield, Watsonville, Soledad, Gonzales, Salinas, Castroville and Chualar. Since the agricultural data is considered proprietary, averages from the sample were presented and analyzed. This final component of the thesis was subdivided into five parts: Implementation Cost Analysis; Industrial Sector Analysis; Urban Sector Analysis; Agricultural Sector Analysis; and Summary Analysis.

1. Implementation Cost Analysis

This thesis analyzed the initial program implementation costs assuming that both the MCWRA allocation program and the theoretical program do not currently exist. When implemented, both will be managed by new, independent divisions of the MCWRA. This assumption means the MCWRA would have to hire new personnel, purchase support equipment and furniture, and lease additional office space to house the new division. The analysis was based on a twelve year period and a four percent discount rate.

Expressed as net present cost, the implementation cost of the proposed program is $13,781,552; while the implementation cost of the MCWRA program is only $2,952,684. The major reason for the difference is the cost of monitoring and enforcing these two programs. The net present cost of the free market program's computerized monitoring and enforcement system is $11,407,098; the MCWRA's program uses technicians to

physically check each well's meter on a quarterly basis. The net present cost of this approach is only $1,382,192. If the free market allocation program operated on an honor system similar to the MCWRA program, where pumping volume is verified quarterly, the net present value to implement this allocation program would be only $3,472,372. The MCWRA's allocation program is much cheaper to implement than the free market program's allocation plan in large part because the free market program envisions a more proactive monitoring and enforcement plan. This requirement is not a unique inherent requirement of this allocation method.

2. Industrial Sector Cost Analysis

The California Products Division of the J. M. Smucker Company is an agricultural processing and packaging plant. This industry segment was selected due to its high water consumption and its economic significance. This division has projected that their water consumption will increase by 5% per year.

Using current water conservation technology, Smucker's can reduce water use by 96 ac-ft annually (65 percent). The annual average cost for the first 7.37 ac-ft of water conserved (5% reduction in water use) is $27 per ac-ft. This five percent reduction would be accomplished by augmenting Smucker's current water conservation program. Smucker can also save an additional 88 ac-ft of (60 percent reduction in water use) using a membrane filtration recycling system. This

latter technology costs $443 per ac-ft of water annually. The preceding cost estimates were used to deter-mine the cost of complying with both allocation programs, based on the assumptions stated in Chapter V. For any given level of water use reduction, the proposed free market allocation program had a lower cost of compliance than the MCWRA's program unless the market price of water is $433 per ac-ft. At this price, Smucker would neither buy or sell water. They would reduce water to exactly the required level through conservation, as with the MCWRA program. In this case, both programs would have a similar cost. Thus, for this company, the proposed free market allocation program is economically preferable to the MCWRA's program.

3. Urban Sector Analysis

The urban sector analysis determined the marginal cost of reducing water use through five methods of water conservation. The marginal cost of reducing water use by one ac-ft per year for each of the five conservation methods are shown below:

1. Low flow showerhead retrofit program: $46 per ac-ft per year.
2. Educational and public information program: $212 per ac-ft per year.
3. Water reclamation program: $400 per ac-ft per year.
4. Ultra low flow toilet retrofit program: $649 per ac-ft per year.
5. Seawater desalinization program: $1050 per ac-ft per year.

These marginal costs were used to determine the cost of compliance for both allocation programs for each urban area in the sample. The MCWRA plan specifies reduction levels for each urban water supplier, irregardless of the marginal cost required to meet this requirement. Under the MCWRA plan, Salinas if forced to conserve 5,253 ac-ft of water in 1994, of which 4,299 ac-ft are conserved through a low-flow showerhead retrofit program at $46/ac-ft and 954 ac-ft are conserved through an information and education program at $212/ac-ft. Marina and Cal Water more than meet their required reductions with only a low flow showerhead retrofit program. Thus, the marginal cost of compliance is higher for Salinas under the MCWRA plan. The regulatory plan allows cheaper sources of water conservation to go untapped because suppliers cannot buy and sell water.

Under the market based plan, urban users can buy and sell water shares and credits both among themselves and with other industries. Thus, the market based plan will always cost less than the MCRWA plan. If the price of water is less than $46/ac-ft, all urban users can meet their water requirements by purchasing water. If the price of water is between $46 and $212/ac-ft, all urban sector suppliers would implement a low flow showerhead retrofit program. Marina and Cal Water would exceed their water reduction requirements and sell their excess water on the open market; Salinas would not satisfy its required reduction, so it would continue to purchase some

water from the market. However, Salinas' purchases are less expensive than the alternative: implementing an education and public information program. If the market price of water exceeds $212/ac-ft, all three suppliers could profit by implementing an education and public information program and selling their excess water. This would further reduce the sector's total compliance costs. Thus, the cost to each supplier and the total sector's cost are lower for the proposed program than for the MCWRA program at all water prices.

As a final note, the MCWRA allocation program ties the annual water consumption of a urban area to its population (i.e., it specifies a per capita water consumption limit based on 1987 per capita water consumption). The Association of Monterey Bay Area Governments (AMBAG) projects that the urban sector population will continue to grow. Thus, the urban demand for water will continue to grow in the future. This is supported by the data received from the City of Salinas and Cal Water.

4. Agricultural Sector Analysis

For the sample from the agricultural sector, the historical average profit margin for cauliflower was -$222 per acre and for broccoli was -$56 per acre from 1988 to 1993. Only lettuce and celery consistently made a profit during the past six years. Furthermore, no government, private, or academic organization has estimated the irrigation efficiency

for specific sites and irrigation methods or the required average water application rates for the major crops grown in the Salinas Valley. Thus, broad assumptions were made in these areas to develop reasonable marginal cost curves for water conservation in the agricultural sector.

The compliance cost for the sample from the agricultural sector is zero under the MCWRA allocation program. Water use in the sample is equal to the historical water use per acre of irrigated crop land in the agricultural sector (2.59 ac-ft of water per year) [Ref. 2:pp. 2-3]. This is less than the amount authorized by the MCWRA's allocation program. The MCWRA's program allows an average farmer in the valley with row crops to use 3.455 ac-ft of water per year for irrigation. (3.455 ac-ft per year is a weighted average of the authorized pumping limit for row crops based on the 1991 distribution of crop land in the four hydrological regions (See Chapter V, p. 203 for details).)

There is no compliance cost for the sample from the agricultural sector with the proposed allocation program either. This program will actually generate a positive revenue stream for the average farmer in the sample. Given the past negative average profit for cauliflower and broccoli, a farmer should choose to sell the water that would have been used to grow cauliflower and broccoli. Water sales would have a greater expected profit than the average loss incurred growing broccoli, and cauliflower. The projected profit

generated for an average farmer in the sample will range from $11,700 to $286,209 per year as the market price of water per ac-ft ranges from $15 to $200. Thus, the sample from the agricultural sector would economically prefer the proposed allocation program rather than the MCWRA program, based on the assumptions stated in Chapter V.

E. SUMMARY ANALYSIS

This analysis has demonstrated that a free market allocation program minimizes compliance costs in every sector for any water use reduction level. This sector by sector analysis clearly supports a free market allocation program. However, the benefits of a free market program become more pronounced when all three sectors are considered simultaneously.

Table 6-4 provides the water use reductions envisioned by the MCWRA and proposed free market allocation program. Furthermore, the agricultural sample in this analysis uses an estimated 16,000 ac-ft of water per year for cauliflower and brocolli. The required water conservation in both programs can be satisfied by reducing the water used for these crops. Both of these crops have had negative average profits for the farmers in the sample over the last six years. Therefore,

cost minimization would imply that water reduction should focus on these crops.

TABLE 6-4. REQUIRED WATER USE REDUCTIONS
(AC-FT PER YEAR)

	Industrial	Urban	Agricultural	Total
MCWRA Regulatory Allocation Program				
1994	69.75	7,879	(16,815)[31]	7,948.75
1995	77.49	8,023	(16,815)	8,100.49
1996	85.62	8,167	(16,815)	8,252.62
Free Market Allocation Program				
1994	17.69	7,782	3,520	11,319.69
1995	25.43	8,734	3,520	12,279.43
1996	33.56	9,705	3,520	13,258.56

Under MCWRA regulatory allocation program, each user in each sector must comply with specific water use limits. Table 6-5 shows the annual costs of complying with both of the above levels of water use reduction under a regulatory allocation system. Under a free market allocation program, the entire water use reduction requirements would be satisfied by reducing cauliflower and broccoli production. Because these crops have negative average profits, the total compliance costs are assumed to be zero. Thus, the total compliance costs for the regulatory program in Table 6-5 represents

[31]Any sector with excess water capacity will be assigned a value of zero when used in calculating the total required water use reduction. This requirement is necessary since the regulatory allocation program can not transfer excess water capacity from one sector to another.

savings under the free market allocation program. Furthermore, farmers could sell any excess water on the open market. This would further increase the savings associated with a free market program. Assuming farmers eliminate cauliflower and broccoli production, Table 6-6 shows the total cost savings of a free market program as the price of water varies from $15 to $100 per ac-ft. At higher market water prices, it might become more profitable for farmers to start withdrawing celery and lettuce from production and selling the excess water. The net profitability of these additional water sales would further increase the benefits of a free market allocation program.

Assuming both the MCWRA and free market programs use the same monitoring plan, the cost savings associated with the free market program will easily exceed the extra costs required to implement this program. As described above, if both programs check pumping rates quarterly, the free market program costs approximately $520,000 more to implement

TABLE 6-5. COMPLIANCE COSTS

MCWRA REGULATORY ALLOCATION PROGRAM					
YR	**Total Water Use Reduction**	**Industrial**	**Urban**	**Agricultural**	**Total**
94	7,949 ac-ft per yr	27,210	520,798	0	548,008
	11,320 ac-ft per yr	4,668	481,144	0	485,812
95	8,100 ac-ft per yr	30,561	530,908	0	561,469
	12,279 ac-ft per yr	8,019	667,032	0	675,051
96	8,253 ac-ft per yr	34,081	540,520	0	574,597
	13,259 ac-ft per yr	11,539	887,636	0	899,175

TABLE 6-5 (CONTINUED)

FREE MARKET ALLOCATION PROGRAM						
YR	Total Water Use Reduction		$15/ac-ft	$30/ac-ft	$75/ac-ft	$100/ac-ft
94	7,949 ac-ft per yr	Industrial Urban Agricultural	1,046 118,185 (492,240)	2,070 236,370 (984,480)	4,878 376,180 (2,461,200)	6,437 3 88,030 (3,281,600)
		Total	(373,009)	(746,040)	(2,080,142)	(2,887,133)
	11,320 ac-ft per yr	Industrial Urban Agricultural	265 116,730 (187,200)	509 233,460 (374,400)	973 368,905 (936,000)	978,5671,231 378,330 (1,248,000)
		Total	(70,205)	(140,431)	(566,122)	(868,439)
95	8,100 ac-ft per yr	Industrial Urban Agricultural	1,162 120,345 (492,240)	2,303 240,690 (984,480)	5,458 384,196 (2,461,200)	7,211 397,246 (3,281,600)
		Total	(370,733)	(741,487)	(2,071,546)	(2,877,143)
	12,279 ac-ft per yr	Industrial Urban Agricultural	381 131,010 (187,200)	741 262,020 (374,400)	1,554 437,521 (936,000)	2,005 468,346 (1,248,000)
		Total	(55,809)	(111,639)	(496,925)	(777,649)
96	8,253 ac-ft per yr	Industrial Urban Agricultural	1,284 122,505 (492,240)	2,547 245,010 (984,480)	6,068 392,154 (2,461,200)	8,024 406,354 (3,281,600)
		Total	(368,451)	(736,923)	(2,062,978)	(2,867,222)
	13,259 ac-ft per yr	Industrial Urban Agricultural	503 145,575 (187,200)	985 291,150 (374,400)	2,163 507,504 (936,000)	2,818 560,154 (1,248,000)
		Total	(41,122)	(82,265)	(426,333)	(685,028)

TABLE 6-6. COST SAVING FOR A FREE MARKET ALLOCATION PROGRAM

YR	Total Water Use Reduction	$15 ac-ft	$30 ac-ft	$75 ac-ft	$100 ac-ft
94	7,949 ac-ft per yr	921,017	1,294,048	2,628,150	3,435,141
	11,320 ac-ft per yr	556,017	626,243	1,051,934	1,354,251
95	8,100 ac-ft per yr	932,202	1,302,956	2,633,015	3,438,612
	12,279 ac-ft per yr	730,860	786,690	1,171,976	1,452,700
96	8,253 ac-ft per yr	943,052	1,311,524	2,637,579	3,441,823
	13,259 ac-ft per yr	940,297	981,440	1,325,508	1,584,203

($3,472,372 - $2,952,684). This cost difference can be recovered by this sample in the first year. If similar cost savings characterize the rest of the SVGB, it is clear the free market program's higher implementation costs will be fully recovered in one year. In fact, the free market program would likely generate enough savings in the first few years to pay for the $11,407,098 (NPC) computerized monitoring system, even at modest water prices.

The analysis also discovered that the MCWRA's allocation program focuses on the urban sector (the industrial sector is a sub-component of the urban sector) and the agricultural

sector. The MCWRA program allows urban sector water use to increase in the future but does not force the agricultural sector to reduce its water use below historical levels. Therefore, the MCWRA allocation program will not bring the Salinas Valley Groundwater Basin back into balance.

This conclusion results from two program requirements. First, the MCWRA allocation program allows the urban sector to increase water use in proportion to increases in population. Furthermore, the urban sector population is expected to increase until 2020 according to data received from AMBAG. Thus, water use in the urban sector can be expected to increase above its current levels until at least the year 2020. This conclusion is supported by the data received from the urban areas in the sample.

Second, the pumping limit for agriculture under the MCWRA allocation program is set at level higher than the historical average annual historical agricultural water use per acre of irrigated crop land. Historical agricultural water use is 2.59 ac-ft/yr per irrigated acre and the upper pumping limit for an average farmer in the valley is 3.455 ac-ft/yr per acre.[32] This upper pumping limit was chosen because "B" and "C" type crops have higher pumping limits than "A" type crops. Therefore, one can assume that the agricultural sector will

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[32]3.455 ac-ft/yr per acre is a weighted average of the authorized pumping limit for Crop "A" type crops (row crops) based on a 1991 distribution of crop land in the four hydrological regions.

not reduce water use since there is no effective requirement to do so.

The MCWRA was questioned on this point and stated it was true that their allocation program would not by itself bring the basin into balance. However, they believe the basin will be in balance in six years, when the Basin Management Plan (BMP) project is completed. The California State Water Board is skeptical that the BMP project will be completed in six years. [Ref. 30:p. 3].

This analysis has established that a free market allocation program is not only feasible, but it is probably more economically efficient than the current MCWRA's allocation program. It is, however, more difficult to operate and maintain than the other two allocation methods discussed in this thesis. While the precise values and responses in this thesis (i.e., withdrawing cauliflower and broccoli from production) depend critically on the assumptions and sample selected, the efficiency of a free market program relative to a regulatory control system would persist for other assumptions and samples. The free market program provides water users with considerable flexibility in responding to water use limits. Users can replicate the inflexible results mandated by a regulatory control system but they have the flexibility and mechanism to find a more efficient response.

The analysis in the thesis should provide sufficient justification for the MCWRA and the County Board of supervisors to discuss the possibility of further research on a

free market allocation system for SVGB. This thesis will hopefully stimulate policy makers and leaders of the communities within the valley to re-open the discussion on how to properly allocate groundwater in the Salinas Valley as well as bring to light the current deficiency in the MCWRA allocation program.

APPENDIX A

LIST OF EQUATIONS

1. Net Present Cost for an Uniform Annual Cost in the Future is:

   $NPC_{i,n}$= (Uniform Annual Cost) X [(1/i) - (1 / (i X $(1+i)^n$))]

   i = Inflation rate, which will always be 4% for this analysis

   n = Number of years being discounted

2. Projected Net Future Cost for Present Cost is:

   $NFC_{i,n}$= (Present Cost) X $(1 + i)^n$

   i = inflation rate, which will always be 4% for this analysis

   n = Number of years projected into the future.

3. Net Present Cost for a Single Future Cost is:

   $NPC_{i,n}$= (Future Cost) X (1 / $(1 + i)^n$)

   i = inflation rate, which will always be 4% for this analysis

   n = Number of years being discounted

4. Uniform Annual Cost in the Future calculated from NPC is

   Uniform Annual Cost = NPC / [(1/i) - (1 / (i X $(1+i)^n$))]

   i = Inflation rate, which will always be 4% for this analysis

   n = Number of years

5. Calculation of NPC for Uniform Annual Cost in Perpetuity

   NPC (Perpetuity) = Uniform Annual Cost / Inflation Rate

6. This calculation is determined by the following method: (For the Industrial and Agricultural sectors skip to step c.)

A) Ordinance Limit for the Urban Sector is determined by:

Ordinance Limit = Pop. X (85% X (Representative's 1987 Wat. / Pop. or Ser.))

B) Required Reduction = Projected Water Demanded - Ordinance Limit

C) The annual economic cost of reducing water use - by the level required each year - is determined from the marginal cost curve. The area underneath the curve, at the required reduction level, is equal to the annual economic cost of reduction. For example: Table 5-1, Required Reduction is 69.75 ac-ft. The area underneath the curve for this level of reduction is equal to: ($27 X 7.37) + ($433 X (69.75 - 7.37)) = $27209.53. All calculations for determining the cost of complinace with MCWRA's program will be calculated in this manner.

7. The economic cost of reduction is calculated in the same manner as in EQ. 6 for the situation where there is no water is available for trade. When water is available it is assumed that a subsample representative will only purchase water up to a price that is equal or less than its own marginal cost of reduction. The water reduction requirement, which is not fulfilled by open market purchase, will be accomplished through internal water conservation programs. The economic cost of reduction is then equal to: Cost of the water purchased + Cost of conservation program (determined by the marginal cost curve). For example, Table 5-2, Market Price of Water is $30/ac-ft, required reduction 17.69 ac-ft. Therefore, economic cost = $509 = Purchase ((17.69 - 7.37) X $30) + Water Conservation program (7.37 X $27).

If the market price of water is greater than the marginal cost of reduction, then it is assumed that the representative will sell any available water that is not required to meet the allocation's program requirements.

Example (On page 44 of the thesis, Calculation: 127)

Compliance Cost = Water Conservation Cost - Revenue From Water Sold (For calculations 124 thru 132)

Water Conservation Cost = (Amount of Water Conserved X Cost per ac-ft of water)

Revenue From Water Sold = (Amount of Water Conserved - Amount of Required Water Reduction) X (Market Price of Water)

Negative Compliance Cost = Profit

-6,876 = (46 X 644) - (100 X (644 - 279))

8. This calculation is determined by the following method:

A. Uniform annual cost using EQ. 4 assuming i =4%, n = 20 years, NPC = $139, $249, $359.

Uniform Annual Cost = NPC / [(1/i) - (1 / (i X $(1+i)^n$))]

10.2279 = $139 / 13.5903
18.3219 = $249 / 13.5903
26.4159 = $359 / 13.5903

B. Cost per saving one ac-ft per year, assuming water savings per year = .02771 ac-ft per yr per toilet.

Cost per yr /ac-ft = Uniform Annual Cost / Water Savings per yr

$369.11 = $10.2279 / .02771 ac-ft
$661.20 = $18.3219 / .02771 ac-ft
$953.30 = $26.4159 / .02771 ac-ft

9. This calculation is determine by the following method:

A. Uniform annual cost using EQ. 4 assuming i =4%, n = 7 years, NPC = $5.99, $11.00, $15.95.

Uniform Annual Cost = NPC / [(1/i) - (1 / (i X $(1+i)^n$))]

$ .9980 = $5.99 / 6.0021
$1.8327 = $11.00 / 6.0021
$2.6574 = $15.95 / 6.0021

B. Cost per saving one ac-ft per year, assuming water savings per year = 12,950 gallons/yr = .03974 ac-ft per yr per showerhead. 325,850 gallons = 1 ac-ft

Cost per yr /ac-ft = Uniform Annual Cost / Water Savings per yr

$25.11 = $.9980 / .03974 ac-ft
$46.12 = $1.8327 / .03974 ac-ft
$66.87 = $2.6574 / .03974 ac-ft

10. This calculation is determine by the following method:

A. Cost per saving one ac-ft per year, assuming water savings per year = 414 ac-ft per yr and the annual cost is $34,000 / yr.

Cost per yr /ac-ft = Uniform Annual Cost / Water Savings per yr

$82.13 = $34,000 / 414 ac-ft

11. This calculation is determine by the following method:

A. Cost per saving one ac-ft per year, assuming water savings per year = 42 ac-ft per yr and the annual cost is $14,360 / yr.

Cost per yr /ac-ft = Uniform Annual Cost / Water Savings per yr

$341.90 = $14,360 / 42 ac-ft

12. The Maximum amount of water that can be reduced for Salinas and Marina is determined by the following calculations:

A. For Low Flow Showerhead Program, assuming 90% population currently do not own low flow showerheads.

Max. Annual Total Water Savings = (population X 90%) X (water savings per year per person using a Low Flow Showerhead)

B. For Information and Education Program, assuming it can reduce water use by 5%.

Max. Annual Total Water Savings = (projected water use) X 5%

C. For Reclamation Program, assuming it can reduce water use by 15%.

Max. Annual Total Water Savings = (projected water use) X 15%

D. For the ULF Toilet Program, assuming 90 % population currently do not own ULF toilets and that ratio of multi to single family residencies is .22. This calculation also assumes that the following characteristics are:

Average Single Family Household has the following characteristic:

Persons per household = 3.0
Toilets per household = 2.2

Average household characteristics for a Multi-Family residency are:

Persons per household = 2.5
Toilets per household = 1.2

No. of toilets available for retrofit = (population X 90%) / (((ratio: single /multi) X (Single Family ratio: Persons / toilets)) + ((ratio: multi / single) X (multi Family ratio: Persons / toilets)))

Max. Annual Water Savings = (No. toilets available) X (Annual Water Savings Per Toilet)

E. Seawater Desalination Program can produce an infinite amount of fresh water given enough resources.

The Maximum amount of water that can be reduced for Cal Water is determined by the following calculations and based on following assumptions:

1) The ratio of multi-residency water use to the total water use growing at linear rate of: '94 11.2%, '95 11.5%, '96 11.8% and single family residency is constant at 48%.

2) The following growth projections are based on prior rates assuming linear relationship for single and multi-family residency:

	Single	Multi
94	177297	6779.5
95	17354	6800.4
96	17410	6821.22

3) On average, there are three persons residing in a single residency and there are on average 2.5 persons residing in a multi-family residency.

A. For Low Flow Showerhead Program, assuming 90% population currently do not own low flow showerheads.

Max. Annual Total Water Savings = (population X 90%) X (water savings per year per person using a Low Flow Showerhead)

Population = (No. of single residency X 3.0 persons / single residency) + (No. of Multi residency X 2.5 persons / Multi)

Annual Water Savings per Showerhead per person = 12,950 gallons = 12,950 / 325,850 = .03974 ac-ft

B. For Information and Education Program, assuming it can reduce water use by 5%.

Max. Annual Total Water Savings = (projected water use) X 5%

C. For Reclamation Program, assuming it can reduce water use by 15%.

Max. Annual Total Water Savings = (projected water use) X 15%

D. For the ULF Toilet Program, assuming 90 % population currently do not own ULF toilets and that ratio of multi to single family residencies is .22. This calculation also assumes that the following characteristics are:

Average Single Family Household has the following characteristic:

Persons per household = 3.0
Toilets per household = 2.2

Average household characteristics for a Multi-Family residency are:

Persons per household = 2.5
Toilets per household = 1.2

Max. Annual Water Savings = (No. Single Residencies X No. of toilets per Single X Annual water savings

per toilet) + (No. Multi Residencies X No. of toilets per Multi X Annual water savings per toilet)

E. Seawater Desalination Program can produce an infinite amount of fresh water given enough resources.

APPENDIX B

LIST OF CALCULATIONS

1. $\$2,753,363 = (\$293,376)[(1/.04)-(1/(.04(1+.04)^{12}))]$
   $i = 4\%,\ n = 12$

2. $\$13,412 = (9,800)(1\ /\ (1\ +\ .04)^{8}$
   $i = 4\%,\ n = 8$

3. $\$33,786 = (\$3,600)[(1/.04)-(1/(.04(1+.04)^{12}))]$
   $i = 4\%,\ n = 12$

4. $\$39,200 = (53,648)[1\ /\ (1\ +\ .04)^{8}]$
   $i = 4\%,\ n = 8$

5. $(\$3,507) = ((\$1,200)(1/(1+.04)^{8})\ X\ 4$
   $i = 4\%,\ n = 8$

6. $\$1,562 = (\$2,500)(\ 1/(1+.04)^{12}$
   $i = 4\%,\ n = 12$

7. $\$53,495 = (\$5,700)[(1/.04)-(1/(.04(1+.04)^{12}))]$
   $i = 4\%,\ n = 12$

8. $\$2,259,857 = (\$240,792)[(1/.04)-(1/(.04(1+.04)^{12}))]$
   $i = 4\%,\ n = 12$

9. $\$5,405,818 = (\$576,000)[(1/.04)-(1/(.04(1+.04)^{12}))]$
   $i = 4\%,\ n = 12$

10. $(\$13,741) = ((\$5,500)(1/(1+.04)^{12})\ X\ 4$
    $i = 4\%,\ n = 12$

    Salvage value = (9800 - 1200)X 50% + 1200 = $5,500

11. $(\$1,998,720) = ((\$3,200,000)(1/(1+.04)^{12})$

    $i = 4\%,\ n = 12$

    Salvage value = $8,000,000 X 40% = $3,200,000

12. Total NPC - Monitoring System - Furniture/computers - Salary = NPC without monitoring program

    NPC for Salary (EQ. 1) =
    $\$277,724 = (\$29,592)[(1/.04)-(1/(.04(1+.04)^{12}))]$

NPC without monitoring program =
\$2,090,180 = 13,781,552 - 11,407,098 - 6,550 - 227,724

13. Total NPC - Transportation - Furniture/computers -Salary

= NPC without monitoring program

NPC for Salary (EQ. 1) =
$\$1,271,268 = (\$135,456)[(1/.04)-(1/(.04(1+.04)^{12}))]$

NPC without monitoring program =
\$1,570,492 = 2,962,898 - 94,938 - 26,200 - 1,271,268

14. NPC under honor system =
= NPC without monitoring program + ((Transportation + Furniture/computers + Salary)= MCWRA monitoring program)

= 2,090,180 + 94,938 + 26,200 + 1,271,268
= \$3,482,586

15. Difference in the NPC of two programs = 3,482,586 - 2,962,898 = \$519,688
Uniform Annual Cost =
$= \$519,688 / [(1/.04) - (1 / (.04 \times (1+.04)^{12}))]$
= \$55,374
i = 4%, n = 12

16. Future Annnual Cost = NPC X i
\$2,800 = \$70,000 X .04

Cost per ac-ft = Annual Cost / Annual Water Savings
\$99.78 per ac-ft = \$2,800 / 28.063 ac-ft

17. Same as 16.
\$4,000 = \$100,000 X .04

Cost per ac-ft = \$542.74 = \$4,000 / 7.37 ac-ft

18.

	NPC
Initial Investment =	\$275,000
Operating Cost	
$\$50,000 / [(1/.04) - (1 / (.04 \times (1+.04)^{10}))] =$	=<u>\$405,545</u>
Total NPC	=\$680,545

Uniform Annual Cost =
$\$680,545 / [(1/.04) - (1 / (.04 \times (1+.04)^{10}))] =$
= \$83,905 per year for 10 yrs

Water Saved = 147.47 ac-ft X 60% = 88.482 ac-ft

Therefore: average cost of saving one ac-ft =
$948.27 = $83,905 / 88.482 ac-ft

19. Cost per ac-ft = $70,000 / 147.47 ac-ft of water
= $515.36 per ac-ft of water annually

20. Cost per ac-ft = Cost of Reduction - Cost of extraction or purchase

A. $27.38 = $542.74 - $515.36
B. $432.91 = $948.27 - $515.36

21. 265 = 15 X 17.69
22. 381 = 15 X 25.43
23. 503 = 15 X 33.56
24. 509 = 30 X (17.69 - 7.37) + (7.37 X 27)
25. 741 = 30 X (25.43 - 7.37) + (7.37 X 27)
26. 985 = 30 X (33.56 - 7.37) + (7.37 x 27)
27. 973 = 75 X (17.69 - 7.37) + (7.37 X 27)
28. 1554 = 75 X (25.43 - 7.37) + (7.37 X 27)
29. 2163 = 75 X (33.56 - 7.37) + (7.37 x 27)
30. 1231 = 100 X (17.69 - 7.37) + (7.37 X 27)
31. 2005 = 100 X (25.43 - 7.37) + (7.37 X 27)
32. 2818 = 200 X (33.56 - 7.37) + (7.37 x 27)
33. 2263 = 200 X (17.69 - 7.37) + (7.37 X 27)
34. 3811 = 200 X (25.43 - 7.37) + (7.37 X 27)
35. 5437 = 200 X (33.56 - 7.37) + (7.37 x 27)

36. (12,950 X (120,197 X.9))/ 325850 = 4299.2 ac-ft, Showerhead
37. (35,025 X .05) = 1751.25, information program
1751 + 4299 = 6050
38. (35,025 X .15) = 5253.75, reclamation program
6050 + 5254 = 11,304
39. [(120,197 X .90) / ((.78 X (3.0 / 2.2)) + (.22 X (2.5 / 1.2)))] X .0271 = 1926.19, toilet replacement program
11,304 + 1926 = 13,230

40. (12,950 X ((17297 X 3) + (6779.5 X 2.5) X.9))/ 325850 = 2462.26 ac-ft, Showerhead
41. (14,784 X .05) = 739.2, information program
2462 + 739 = 3201
42. (14,784 X .15) = 2217.6, reclamation program
3201 + 2218 = 5419
43. [(17297 X 2.2 X .0223) + (6779.5 X 1.2 X .0442)] = 1,208, toilet replacement program
5419 + 1,208 = 6627

44. 1:(12,950 X (18,000 X.9))/ 325850 = 643.82 ac-ft
45. 2:(2,729 X .05) = 136.45
644 + 136 = 780

46. 3:(2,729 X .15) = 409.35
780 + 409 = 1,189
47. 4:[(18,000 X .90) / ((.78 X (3.0 / 2.2)) + (.22 X (2.5 / 1.2)))] X .0271 = 668.175
1,189 + 668 = 1,857

48. 1:(12,950 X (122,655 X.9))/ 325850 = 4387.123 ac-ft, Showerhead
49. 2:(35,742 X .05) = 1787.1, information program
4387 + 1787 = 6174
50. 3:(35,742 X .15) = 5361.3, reclamation program
6174 + 5361 = 11535
51. 4:[(122,655 X .90) / ((.78 X (3.0 / 2.2)) + (.22 X (2.5 / 1.2)))] X .0271 = 1965.58, toilet replacement program
11535 + 1966 = 13501

52. (12,950 X (((17354 X 3) + (6800.4 X 2.5)) X.9))/ 325850 = 2,470.24 ac-ft, Showerhead
53. (15,019 X .05) = 739.2, information program
2,470 + 739 = 3,209
54. (15,019 X .15) = 2217.6, reclamation program
3,209 + 2,218 = 5,427
55. [(17354 X 2.2 X .0223) + (6800.4 X 1.2 X .0442)] = 1,212.08, toilet replacement program
5,427 + 1,212 = 6,639

56. (12,950 X (18,000 X.9))/ 325850 = 643.82 ac-ft
57. (2,729 X .05) = 136.45
644 + 136 = 780
58. (2,729 X .15) = 409.35
780 + 409 = 1189
59. [(18,000 X .90) / ((.78 X (3.0 / 2.2)) + (.22 X (2.5 / 1.2)))] X .0271 = 668.175
1189 + 688 = 1877

60. (12,950 X (125,163 X.9))/ 325850 = 4476.83 ac-ft, Showerhead
61. (36,472 X .05) = 1823.6, information program
4477 + 1824 = 6,301
62. (36,472 X .15) = 5470.8, reclamation program
6,301 + 5471 = 11,772
63. [(125,163 X .90) / ((.78 X (3.0 / 2.2)) + (.22 X (2.5 / 1.2)))] X .0271 = 2005.773, toilet replacement program
11,772 + 2006 = 13,778

64. (12,950 X ((17410 X 3) + (6821.22 X 2.5) X.9))/ 325850 = 2,478.1 ac-ft, Showerhead
65. (15,260 X .05) = 763, information program
2,478 + 763 = 3,241
66. (15,260 X .15) = 2289, reclamation program
3,241 + 2,289 = 5,530

67. [(17410 X 2.2 X .0223) + (6821.22 X 1.2 X .0442)] = 1,215.93, toilet replacement program
5,530 + 1,216 = 6,746

68. (12,950 X (18,000 X.9))/ 325850 = 643.82 ac-ft
69. (2,729 X .05) = 136.45
644 + 136 = 780
70. (2,729 X .15) = 409.35
780 + 409 = 1,189
71. [(18,000 X .90) / ((.78 X (3.0 / 2.2)) + (.22 X (2.5 / 1.2)))] X .0271 = 668.175
1,189 + 668 = 1,857

72. (4,299 ac-ft X $46/ac-ft) + (954 ac-ft X $212/ac-ft) = $400,002
73. (4,387 ac-ft X $46/ac-ft) + (975 ac-ft X $212/ac-ft) = $408,502
74. (4,477 ac-ft X $46/ac-ft) + (993 ac-ft X $212/ac-ft) = $416,458

75. $101,982 = 2,217 ac-ft X $46/ac-ft
76. $103,592 = 2,252 ac-ft X $46/ac-ft
77. $105,248 = 2,288 ac-ft X $46/ac-ft

78. $18,814 = 409 ac-ft X $46/ac-ft

City of Salinas

79. 350,394 = (46 X 4,299) + (212 X 720)
80. 487,790 = (46 X 4,387) + (212 X 1349)
81. 658,630 = (46 X 4,477) + (212 X 1824) + (400 X 165)

82. 75,285 = 5019 X 15
83. 86,040 = 5,736 X 15
84. 96,990 = 6,466 X 15

85. 150,570 = 5019 X 30
86. 172,080 = 5,736 X 30
87. 193,980 = 6,466 X 30

88. 251,754 = (46 X 4,299) + (75 X 720)
89. 302,977 = (46 X 4,387) + (75 X 1349)
90. 355,117 = (46 X 4,477) + (75 X 1989)

91. 269,754 = (46 X 4,299) + (100 X 720)
92. 336,702 = (46 X 4,387) + (100 X 1349)
93. 404,842 = (46 X 4,477) + (100 X 1989)

94. 341,754 = (46 X 4,299) + (200 X 720)
95. 471,602 = (46 X 4,387) + (200 X 1349)
96. 603,742 = (46 X 4,477) + (200 X 1989)

Cal Water

97. 117,916 = (46 X 2,462) + (212 X 22)
98. 166,408 = (46 X 2,470) + (212 X 249)
99. 216,172 = (46 X 2,478) + (212 X 482)

100. 37,260 = 2,484 X 15
101. 40,785 = 2,719 X 15
102. 44,400 = 2,960 X 15

103. 74,520 = 2,484 X 30
104. 81,570 = 2,719 X 30
105. 88,800 = 2,960 X 30

106. 114,902 = (46 X 2,462) + (75 X 22)
107. 132,295 = (46 X 2,470) + (75 X 249)
108. 150,138 = (46 X 2,478) + (75 X 482)

109. 115,452 = (46 X 2,462) + (100 X 22)
110. 138,520 = (46 X 2,470) + (100 X 249)
111. 162,188 = (46 X 2,478) + (100 X 482)

112. 117,652 = (46 X 2,462) + (200 X 22)
113. 163,420 = (46 X 2,470) + (200 X 249)
114. 210,388 = (46 X 2,478) + (200 X 482)

Marina

115. 12,834 = 279 X 46
116. 12,834 = 279 X 46
117. 12,834 = 279 X 46

118. 4,185 = 279 X 15
119. 4,185 = 279 X 15
120. 4,185 = 279 X 15

121. 8,370 = 279 X 30
122. 8,370 = 279 X 30
123. 8,370 = 279 X 30

Compliance Cost = Water Conservation Cost - Revenue From Water Sold (For calculations 124 thru 132)

Water Conservation Cost = (Amount of Water Conserved X Cost per ac-ft of water)

Revenue From Water Sold = (Amount of Water Conserved - Amount of Required Water Reduction) X (Market Price of Water)

Negative Compliance Cost = Profit

124. 2,249 = (46 X 644) - (75 X (644 -279))

125. 2,249 = (46 X 644) - (75 X (644 -279))
126. 2,249 = (46 X 644) - (75 X (644 -279))

127. -6,876 = (46 X 644) - (100 X (644 - 279))
128. -6,876 = (46 X 644) - (100 X (644 - 279))
129. -6,876 = (46 X 644) - (100 X (644 - 279))

130. -43,376 = (46 X 644) - (200 X (644 - 279))
131. -43,376 = (46 X 644) - (200 X (644 - 279))
132. -43,376 = (46 X 644) - (200 X (644 - 279))

Urban Sector's Marginal Cost Curve Calculations:
1994

133. 7,405 = 4,299 + 2,462 + 644
134. 10,031 = 6,050 + 3,201 + 780
135. 17,912 = 11,304 + 5,419 + 1,189
136. 21,714 = 13,230 + 6,627 + 1,857

1995
137. 7,501 = 4,387 + 2,470 + 644
138. 10,163 = 6,174 + 3,209 + 780
139. 18,151 = 11,535 + 5,427 + 1,189
140. 22,017 = 13,501 + 6,639 + 1,877

1996
141. 7,599 = 4,477 + 2,478 + 644
142. 10,322 = 6,301 + 3,241 + 780
143. 18,491 = 11,772 + 5,530 + 1,189
144. 22,381 = 13,778 + 6,746 + 1,857

145. 2.588 Ac-ft = 512,000 ac-ft per year / 197,827 crop acre based on information provided by [Ref. 2]

146. Uniform Annual Cost = NPC / $[(1/i) - (1 / (i \times (1+i)^n))]$
i = 4%, n = 10 yrs.

$65.46 = $531 / 8.1109
$36.98 = $300 / 8.1109
$12.33 = $100 / 8.1109

147. 3.445 = [.2645 X ((2.33 + 2.56 + 3.23) / 3)] + [.1842 X ((2.84 + 3.00) / 2)] + [.2921 X 3.89] + [.2592 X 4.11]

148. $140.54 = $364 (Profit per Acre) / 2.59 ac-ft (amount of Water used per acre)

149. $133.20 = $345 (Profit per Acre) / 2.59 ac-ft (amount of Water used per acre)

150. 999.74 ac-ft = (194 ac + 192 ac) X 2.59 ac-ft of water per acre

151. 349.65 ac-ft = 135 ac X 2.59 ac-ft of water per acre
1,000 ac-ft + 350 ac-ft = 1350 ac-ft

152. 1,797.46 ac-ft = 694 ac X 2.59 ac-ft of water per acre
1,350 ac-ft + 1,797 ac-ft = 3,147 ac-ft

Profit = Market Price of Water X No. of Representatives X (Acreage of Crop Land Economically Viable to take out of production - Acreage of Crop Land Required to take out of production)

153. $187,200 = 16 X (($15 X (1000 ac-ft - 220 ac-ft) - 0)
154. $374,400 = 16 X (($30 X (1000 ac-ft - 220 ac-ft) - 0)
155. $936,000 = 16 X (($75 X (1000 ac-ft - 220 ac-ft) - 0)
156. $1,248,000 = 16 X (($100 X (1000 ac-ft - 220 ac-ft) - 0)
157. $4,579,344 = 16 X ((($200 X (3,147 ac-ft - 220 ac-ft) - (694 ac. X $364/ac.) - (135 ac. X $345/ac.))

Profit = Market Price of Water X (Acreage of Crop Land Economically Viable to take out of production - Acreage of Crop Land Required to take out of production - forgone profit on crops removed)

158. $11,700 = ($15 X (1000 ac-ft - 220 ac-ft)) - 0
159. $23,400 = ($30 X (1000 ac-ft - 220 ac-ft)) - 0
160. $58,500 = ($75 X (1000 ac-ft - 220 ac-ft)) - 0
161. $78,000 = ($100 X (1000 ac-ft - 220 ac-ft)) - 0
162. $286,209 = ($200 X (3,147 ac-ft - 220 ac-ft)) - (694 ac. X $364/ac.) - (135 ac. X $345/ac.

163. $256.42 = ($53.13/yr) / (2.59 ac-ft/yr X (.74 - .66))
164. $951.74 = ($24.65/yr) / (2.59 ac-ft/yr X (.67 - .66))

LIST OF REFERENCES

1. Monterey County Water Resources Agency, Groundwater Extraction Management Study Report, Monterey County Water Resources Agency, November 1992.

2. Montgomery Watson Engineering Group, MCWRA Salinas River Basin Water Resources Management Plan - Task 1.09, Salinas Valley Groundwater Flow and Quality Model Report Valley IGSM Groundwater Model, Monterey County Water Resources Agency, February 1994.

3. Youngblood, Richard A., Interview by LT Thomas C. Luetzow, 26 May 1994. Telephone Interview, Marina Coast Water District, Marina, CA.

4. Howard, Lauran L., and Shifflett, Deborah, Interviewed by LT Thomas C. Luetzow, 25 March 1994, Monterey County Water Resources Agency, Salinas, CA.

5. Danyal Kasapligil, California Mobile Irrigation Labs, Mobile Irrigation Lab Monterey County Water Resources Agency, Salinas, CA.

6. United States Department of Agriculture Soil Conservation Service, Irrigation System Evaluation, U.S.D.A., 1990.

7. Agricultural Commissioner, 1993 Monterey County Agricultural Crop Report, Monterey County Agricultural Commissioner's Office, Salinas, CA.

8. The Monterey County Flood Control and Water Conservation District, Water Capital Facility Plan (Draft), V. 1, August 15, 1990.

9. Neagley, John P., and O'Brien, Robert T., Market Allocation of Agricultural Water Resources in the Salinas River Valley, MS. Thesis., United States Naval Postgraduate School, 1990.

10. Montgomery Watson Engineering Group, A Summary of Engineering and Hydrologic Analysis, Salinas River Basin Management Plan, Monterey County Water Resources Agency, January 6, 1994.

11. Anderson, Terry L., Water Rights (Scarce Resource Allocation, Bureaucracy, and the Environment, Cambridge: Ballinger Publishing Company, 1983.

12. Henderson, David R., The Fortune Encyclopedia of Economics, New York: Warner Books, Inc., 1993.

13. Pindyck, Robert S., and Rubinfeld, Daniel L., Microeconomics, 2nd Edition, New York: Macmillan Publishing Company, 1992.

14. Mandel, S., and Shiftan, Z. L., Groundwater Resources (Investigation and Development), New York: Academic Press, 1981.

15. Gwartney, James D., and Stroup, Richard L., Macroeconomics (Private and Public Choice), 6th Edition, New York: The Dryden Press, 1992.

16. Rentc, William., Interviewed by LT Thomas C. Luetzow, 17 March 1994, Legal Council for the Monterey County Board of Supervisors, Salinas, CA.

17. Tietenberg, Thomas H., Transferable Discharge Permits and the Control of Stationary Source Air Pollution, in Dorfman, Nancy, Dorfman, Robert., ed., Economics of the Environment (Selected Readings), New York: W. W. Norton & Company, 1993.

18. Anderson, Terry L., Water Crisis (Ending the Policy Drought), Baltimore: Johns Hopkins University Press, 1983.

19. Graubard, Morlie H., and Moore, Nancy Y., and Phelps, Charles E., Efficient Water Use in California: Water Rights, Water Districts, and Water Transfers, Rand Corporation, Rand Report R-2386-CSA/RF, November 1978.

20. South Coast Air Quality Management District, The Regional Clean Air Incentives Market (RECLAIM), Final, South Coast Air Quality Management District, Los Angeles, CA, October 1993.

21. Schifflett, Deborah, Interviewed by LT Thomas C. Luetzow, Telephone Conversation, 30 March 94, Water Conservationist at Monterey County Water Resources Agency, Salinas, CA.

22. Monterey County Auditor Office, Interviewed by LT Thomas C. Luetzow, Telephone Conversation, 4 April 94, Monterey County, Salinas, CA.

23. Guardino, Donna B., Interviewed by LT Thomas C. Luetzow, 7 April 94, Buyer II at with Donna B. Guardino, Buyer II at County of Monterey Purchasing Office Support Services Division, Salinas, CA.

24. Skripka, Fred J., Interviewed by LT Thomas C. Luetzow, Telephone Conversation, 29 April 94, Fleet Manager of the Monterey County Fleet Management, Salinas, CA.

25. Industry Advisory Technical Committee of the NFPA and CCLFP, Survey of Water Use in the California Food Processing Industry, National Food Processors Association (NFPA) and California League of Food Processors (CLFP), 1994.

26. Clay, Wayne, Interviewed by LT Thomas C. Luetzow, Telephone Conversation, 4 May 94, County of Monterey, Department of Public Works - Environmental Services Division, Salinas, CA.

27. Office of Economic Development, Salinas, The Place to Grow, City of Salinas - Office of Economic Development, February 1989.

28. Aguilar, Donna, Interviewed by LT Thomas C. Luetzow, Telephone Conversation, 26 May 94, Water Conservationist at California Water Service Company, San Jose, CA.

29. Marina Coast Water District, 1992 MCWD Urban Water Management Plan, Marina Coast Water District, Marina, CA, May 1992.

30. Pettit, Walt, Executive Director, A Letter to MCWRA, Subj: Salinas Valley Groundwater Basin Seawater Intrusion, Division of Water Rights of the State of California Water Resources Control Board, September 10, 1993.

31. Schulbach, Kurt, Season Long Crop Water Use and Irrigation Efficiency Evaluation, Monterey County Agricultural Extension Service, Salinas CA, March 1988.

32. Bonnita, Ruth, Interviewed by LT Thomas C. Luetzow, 14 March 94, Product and Technical Development Manager, J. M. Smucker Company, California Farm Products Division, Salinas, CA.

33. Buzzelli, Buzz, and others, How to Get Water Smart (Products and Practices For Saving Water in the Nineties, Terra Firma Publishing, 1993.

BIBLIOGRAPHY

Agricultural Commissioner, 1993 Monterey County Agricultural Crop Report, Monterey County Agricultural Commissioner's Office, Salinas, CA.

Aguilar, Donna., Interviewed by LT Thomas C. Luetzow, Telephone Conversation, 26 May 94, Water Conservationist at California Water Service Company, San Jose, CA.

Anderson, Terry L., Water Crisis (Ending the Policy Drought), Baltimore: Johns Hopkins University Press, 1983.

Anderson, Terry L., Water Rights (Scarce Resource Allocation, Bureaucracy, and the Environment, Cambridge: Ballinger Publishing Company, 1983.

Bagley, Edgar S., Water Rights Law and Public Policies Relating to Groundwater 'Mining' in the Southwestern States, Journal of Law and Economics 4 (October 1961): 152.

Bonnita, Ruth., Interviewed by LT Thomas C. Luetzow, 14 March 94, Product and Technical Development Manager, J. M. Smucker Company, California Farm Products Division, Salinas CA.

Boyle Engineering Corp., Salinas Valley Groundwater Model for Monterey County Flood Control & Water Conservation District, Monterey County Flood Control & Water Conservation District, Salinas CA, July 1986.

Buzzelli, Buzz, and others, How to Get Water Smart (Products and Practices For Saving Water in the Nineties, Terra Firma Publishing, 1993.

California Urban Water Conservation Council, Assumptions and Methodology for Determining Estimates of Reliable Water Savings from the Installation of ULF Toilets, Exhibit 6, California Urban Water Conservation Council, July 1992.

Callahan, Kevin, Interviewed by LT Thomas C. Luetzow, 15 March 94, Principal Planner at Department of Community Development of the City of Salinas, Salinas, CA.

Clay, Wayne, Interviewed by LT Thomas C. Luetzow, Telephone Conversation, 4 May 94, County of Monterey, Department of Public Works - Environmental Services Division, Salinas, CA.

Crawford, Malcom, Interviewed by LT Thomas C. Luetzow, 16 March 94, General Manager at Marina Coast Water District, Marina, CA.

Demesetz, Harold., Toward a Theory of Property Rights, American Economic Review 57 (May 1967): 354.

Department of Public Works, Salinas Basin Investigation, State of California, Department of Public Works, Division of Water Resources, 1946.

Gonwa, Rick, Interviewed by LT Thomas C. Luetzow, Telephone Conversation, 12 April 94, Sales Representative for General Electric Inc. - Capital, Modular Space Division.

Graubard, Morlie H., and Moore, Nancy Y., and Phelps, Charles E., Efficient Water Use in California: Water Rights, Water Districts, and Water Transfers, Rand Corporation, Rand Report R-2386-CSA/RF, November 1978.

Guardino, Donna B., Interviewed by LT Thomas C. Luetzow, 7 April 94, with Donna B. Guardino, Buyer II at County of Monterey Purchasing Office Support Services Division, Salinas CA.

Gwartney, James D., and Stroup, Richard L., Macroeconomics (Private and Public Choice), 6th Edition, New York: The Dryden Press, 1992.

Henderson, David R., ed., The Fortune Encyclopedia of Economics, New York: Warner Books, Inc., 1993.

Howard, Lauran L., and Shifflett, Deborah., Interviewed by LT Thomas C. Luetzow, 25 March 1994, Monterey County Water Resources Agency, Salinas, CA.

Industry Advisory Technical Committee of the NFPA and CCLFP, Survey of Water Use in the California Food Processing Industry, National Food Processors Association (NFPA) and California League of Food Processors (CLFP), 1994.

Johnson, Martin, Interviewed by LT Thomas C. Luetzow, 21 March 94, Northern Region, Agricultural Manager, Dole Foods Inc., Fresh Vegetable Division, Soledad, CA.

Kasapligil, Danyal, California Mobile Irrigation Labs, Mobile Irrigation Lab Monterey County Water Resources Agency, Salinas, CA.

Kasapligil, Danyal, Interviewed by LT Thomas C. Luetzow, 11 February 94, Irrigation Expert at Monterey County Water Resources Agency, Salinas, CA.

Killip, John T., Interviewed by LT Thomas C. Luetzow, 22 April 94, President at West Plant Systems, Inc., Carmel, CA.

Lipson, Albert J., Efficient Water Use in California: The Evolution of Groundwater Management in Southern California, Santa Monica, CA: The Rand Corporation, 4-2387/2 - CSA/RF, November 1978.

Mandel, S., and Shiftan, Z.L., Groundwater Resources (Investigation and Development), New York: Academic Press, 1981.

Marina Coast Water District, Joint Water Allocation and Conservation Plan for Water Years 1994, 1995, 1996, Marina Coast Water District, Marina, CA, 1 March 1994.

Marina Coast Water District, 1992 MCWD Urban Water Management Plan, Marina Coast Water District, Marina, CA, May 1992.

Monterey County Water Resources Agency, Groundwater Extraction Management Study Report, Monterey County Water Resources Agency, November 1992.

Monterey County Auditor Office, Interviewed by LT Thomas C. Luetzow, Telephone Conversation, 4 April 94, Monterey County, Salinas, CA.

Monterey County Flood Control and Water Conservation District, Water Capital Facility Plan (Draft), V. 1, August 15, 1990.

Montgomery Watson, Groundwater Model Development Presentation of Preliminary Results, Monterey County Water Resources Agency, Salinas, CA, April 1993.

Montgomery Watson Engineering Group, MCWRA Salinas River Basin Water Resources Management Plan - Task 1.09, Salinas Valley Groundwater Flow and Quality Model Report Valley IGSM Groundwater Model, Monterey County Water Resources Agency, February 1994.

Montgomery Watson Engineering Group, A Summary of Engineering and Hydrologic Analysis, Salinas River Basin Management Plan, Monterey County Water Resources Agency, January 6, 1994.

National Economic Research Associates, Inc., Market-Based Approaches to Reduce the Cost of Clean Air in California's South Coast Basin, California Council for Environmental and Economic Balance, Cambridge, MA, 28 November 1990.

Neagley, John P., and O'Brien, Robert T., Market Allocation of Agricultural Water Resources in the Salinas River Valley, MS. Thesis, United States Naval Postgraduate School, 1990.

Office of Economic Development, Salinas, The Place to Grow, City of Salinas - Office of Economic Development, February 1989.

Pettit, Walt, Executive Director, A Letter to MCWRA, Subj: Salinas Valley Groundwater Basin Seawater Intrusion, Division of Water Rights of the State of California Water Resources Control Board, September 10, 1993.

Phelps, C.E., and others, Efficient Water Use in California: Executive Summary, Rand Corporation, R-32385-CSA/RF, November 1978.

Pindyck, Robert S., and Rubinfeld, Daniel L., Microeconomics, 2nd Edition, New York: Macmillan Publishing Company, 1992.

Rentc, William, Interviewed by LT Thomas C. Luetzow, 3 February 1994, Legal Council for the Monterey County Board of Supervisors, Salinas, CA.

Rhoads, Steven E., The Economist's View of the World (Government, Markets, and Public Policy), Cambridge: Cambridge University Press, 1985.

Roe, David, Dynamos and Virgins, New York: Random House, 1984.

Salinas, City of, Urban Water Allocation Plan and Ordinance, City of Salinas Principal Planner, 8 March 1994.

Schifflett, Deborah, Interviewed by LT Thomas C. Luetzow, Telephone Conversation, 30 March 94, Water Conservationist at Monterey County Water Resources Agency, Salinas, CA.

Schulbach, Kurt, Season Long Crop Water Use and Irrigation Efficiency Evaluation, Monterey County Agricultural Extension Service, Salinas, CA, March 1988.

Skripka, Fred J., Interviewed by LT Thomas C. Luetzow, Telephone Conversation, 29 April 94, Fleet Manager of the Monterey County Fleet Management, Salinas, CA.

Smith, James E., Interviewed by LT Thomas C. Luetzow, 17 March 94, District Manager at California Water Service Company, Salinas, CA.

Smucker Company, J.M., 1993 Annual Report and Form 10K, J.M. Smucker Company, Orrville, Ohio, 30 April 1993.

South Coast Air Quality Management District, The Regional Clean Air Incentives Market (RECLAIM), Final, South Coast Air Quality Management District, Los Angeles, CA, October 1993.

Tietenberg, Thomas H., Transferable Discharge Permits and the Control of Stationary Source Air Pollution, in Dorfman, Nancy, Dorfman, Robert., ed., Economics of the Environment (Selected Readings), New York: W. W. Norton & Company, 1993.

United States Department of Agriculture Soil Conservation Service, Irrigation System Evaluation, U.S.D.A., 1990.

Whitney, Victoria, Interviewed by LT Thomas C. Luetzow, Telephone Conversation, 11 May 94, Division of Water Rights, State of California Water Resources Control Board, Sacramento CA.

Win, Dr. U., Interviewed by LT Thomas C. Luetzow, 11 February 94, Hydrologist at Monterey County Water Resources Agency, Salinas, CA.

Youngblood, Richard A., Interview by LT Thomas C. Luetzow, 26 May 1994. Telephone Interview, Marina Coast Water District, Marina, CA.

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10. The Clerk of the Monterey County Board of Supervisors 1
240 Church St.
Salinas, CA 93901

11. Chairman of the Board of Directors 1
Monterey County Water Resources Agency
855 E. Laurel Avenue
Salinas, CA 93905

12. Victoria Whitney 1
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